Three Essays on Corporate Cash Policy and Financial Markets

Dissertation

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Part I: Introduction

Financial markets have feedback effects on the real economy due to the informational role of security prices (Bond, Edmans, and Goldstein, 2012). This concept goes back to Hayek (1945), who argues that society can share information through the price system. Economic agents make decisions based on the information learned from security prices (Baumol, 1965; Bond, Goldstein and Prescott, 2010). Corporate managers are influenced by the prices in financial markets when making corporate policies (Dow and Gorton, 1997; Subruhmanyam and Titman, 1999; Luo, 2005; Chen, Goldstein and Jiang, 2007; Bakke and Whited, 2010; Fresard, 2012; Edmans, Goldstein, and Jiang, 2012; Hau and Lai, 2013). This dissertation studies how and why factors in financial markets affect corporate policies, particularly the cash policy.

A fundamental objective in the research on corporate cash policy is to understand why firms hold so much cash, given the relatively low rate of return. Bates, Kahle and Stulz (2009) demonstrate that on average, US industrial firms more than doubled their cash holdings from 1980 to 2006 and held cash worth more than 20% of their total assets from 2000 to 2006. Corporate cash holdings may be driven by different motives, including transaction motives (Baumol, 1952; Miller and Orr, 1966; and Mulligan, 1997), tax motives (Foley, Hartzell, Titman, and Twite, 2007), agency motives (Jensen, 1986; Dittmar, Mahrt-Smith, and Servaes, 2003; Dittmar and Mahrt-Smith, 2007; Pinkowitz, Stulz, and Williamson, 2006; Harford, Mansi, and Maxwell, 2008; Chava and Purnanandam, 2010; Liu and Mauer, 2011), and precautionary motives (Keynes, 1936; Opler, Pinkowitz, Stulz and Williamson, 1999; Almeida, Campello, and Weisbach, 2004; Han and Qiu, 2007; Acharya, Almeida, and Campello, 2007; Bates, Kahle and Stulz, 2009; McLean, 2011).

This dissertation demonstrates that the feedback effect of financial markets can affect corporate cash holdings. The mechanism relies on the informativeness of security prices and the precautionary motive of cash holdings. Corporate managers and other stakeholders, such as customers, suppliers, and capital providers, take actions based on the information learned from security prices. These actions may affect future corporate cash flows and generate new investment opportunities (Subruhmanyam and Titman, 2001). Because of the friction of external financing, precautionary motives drive firms to hoard cash in advance (Huberman, 1984; Acharya, Almeida, and Campello, 2007).

This dissertation includes three research papers, two of which are empirical studies and one of which illustrates a mechanism through a theoretical model. The first paper focuses on the effect of stock market liquidity on corporate cash holdings. This paper provides empirical evidence that stock market liquidity has a positive impact on cash holdings. The two main competing hypotheses are cascade hypothesis and financial constraints hypothesis. Subrahmanyam and Titman (2001) study the cascade mechanism through which stock prices affect cash flows. In this paper, the cascade hypothesis states that firms with more liquid stocks need more cash holdings to avoid negative cascades or to stimulate positive cascades, whereas the financial constraints hypothesis states that firms with more liquid stocks need less cash holdings because more liquid stocks indicate less cost of external financing and then less financial constraints. The empirical findings support the

cascade hypothesis. Causality is carefully tested through a decimalization test, which is designed based on the tick decimalization in stock markets in 2001. Furthermore, a test by a system of simultaneous equations suggests that there is a two-way causality between stock market liquidity and cash holdings.

The second paper studies the causal impact of stock short sales on corporate cash holdings. Short sellers benefit from the drop of stock prices, which provides strong incentive to dig on the dark side of firms. For example, short sellers actively investigate target firms and aggressively spread negative research reports among stakeholders (e.g. capital providers, customers, suppliers, and employees). Short sales facilitate the incorporation of negative information into stock prices. Attacks of short sellers isolate firms from stakeholders, increase the cost of external financing, and decrease operational cash flow. Firms should be wary of short selling activities in financial markets. Precautionary motive drives the firms hold cash as the ammunition for the battle with short sellers and as unconditional liquidity support during negative events. This paper provides empirical evidence that short-selling pressure has a positive impact on cash holdings. The results are robust after controlling for relevant firm characteristics, heterogeneity of belief, investors' holding horizons, institutional monitoring incentives, and other information channels (such as financial analysts). A test by a system of simultaneous equations supports the causal impact of short sales on cash holdings and excludes the reverse causality. This paper also sheds light on a better understanding of the determinants of short-selling activities in financial markets.

The third paper proposes a theoretical model to demonstrate a mechanism by which financial markets affect corporate policies when managers do not learn from financial markets. The existing research on the real effect of financial markets on corporate policies depends on the assumption that corporate managers learn from prices in financial markets when making corporate policies (Chen, Goldstein and Jiang, 2007; Bond, Goldstein and Prescott, 2010; Edmans, Goldstein, and Jiang, 2012; Fresard, 2012). The manager-learning argument is reasonable and intuitive. However, given the fact that managers naturally have an informational advantage with regard to the firms they operate, will financial markets affect corporate policies if managers do not need to learn from financial markets? This paper suggests a channel based on the interaction between managers and other stakeholders. This paper extends the idea in Subruhmanyam and Titman (2001) by considering financial constraints of the new investment and adding a firm manager in the model structure. The manager has private information and does not need to learn from financial market. However, other stakeholders, such as customers, suppliers, capital providers, may learn from security prices, and their actions affect corporate cash flows and may generate new investment opportunities. Therefore, even if managers do not need to learn from financial markets, they still can not ignore financial markets when making corporate policies.

This dissertation has the following contributions. First, it contributes to cash holding literature by specifying factors in financial markets as determinants of corporate cash holdings. For example,

stock market liquidity and stock short sales both have positive impacts on cash holdings. Second, the empirical papers in this dissertation provide direct evidence that financial markets have feedback effects on real economy and are not just a sideshow. Finally, the theoretical paper in this dissertation supplements the literature by demonstrating a mechanism that financial markets affect corporate policies even when managers do not learn from the financial markets. It facilitates a better understanding of the informative role of security prices in financial markets.

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Part II: Research Papers

Stock Liquidity and Corporate Cash Holdings *†

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Abstract

The literature on corporate cash holdings show that these are affected by firm characteristics such as size, market-to-book, etc. We argue that there is also a financial markets channel and, in particular, that the liquidity of a corporation's stock influences its cash holdings. Evidence exists in the literature that stock liquidity and cash holdings are linked, with the main idea being that a higher cash ratio reduces information asymmetries and therefore enhances liquidity. But causality can also flow the other way, and this is not examined or controlled for in the literature. Our main focus is on the idea that firms with more liquid stocks hold more cash as ammunition to fend off negative cascades or stimulate positive ones. The evidence is supportive. Furthermore, the cash ratio sensitivity to stock liquidity is higher for firms with larger growth options. As robustness checks to our basic results, we (i) use the introduction of tick size decimalization in 2001 as a natural experiment where liquidity was exogenously shocked and (ii) run a system of simultaneous equations where cash holdings and liquidity are jointly determined. Our findings support the view that there is two-way causality; a higher level of stock liquidity leads to more cash holdings, and vice versa.

Keywords: Stock liquidity, cash holdings, cascades, information
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1 Introduction

Over the past three decades, US corporations have increased the fraction of their assets held as cash (Bates, Kahle, and Stulz, 2009). Much has also been made by the financial press of these seemingly large cash holdings over the course of the financial crisis. The literature discusses both potential costs and benefits of corporate cash holdings; for example, agency costs (Jensen, 1986), on the one hand, and benefits from avoiding the need to tap into external markets, on the other (Myers and Majluf, 1984; Opler, Pinkowitz, Stulz, and Williamson, 1999; Sufi, 2009; Lins, Servaes and Tufano, 2010). With respect to the determinants of corporate cash holdings, the literature has predominantly focused on firm characteristics; for example, size, leverage, market-to-book, cash flow volatility, and measures of financial constraints (Opler, Pinkowitz, Stulz and Williamson, 1999; Almeida, Campello, and Weisbach, 2004; Han and Qiu, 2007; Acharya, Almeida, and Campello, 2007; Bates, Kahle and Stulz, 2009). In this paper, we argue that there is also a channel from financial markets that affect corporate cash holdings. In particular, we provide evidence that the liquidity of a corporation's stock affects its cash holdings.

Theory suggests that a corporation's cash holdings and the liquidity of its stock are related. For example, the larger is the fraction of the firm's assets that is comprised of cash, the smaller should informational asymmetries be and, thus, according to standard market microstructure reasoning (Bagehot, 1971; Glosten and Milgrom, 1985; and Kyle, 1985), the more liquid should the stock be. Evidence in support of this view is provided by Gopalan, Kadan, and Pevzner (2012). But causality can also flow the other way, and this is not examined or controlled for by Gopalan et al. In contrast, in this paper we make the case for two-way causality, by examining the empirical relation between cash holdings and stock liquidity.

Our motivation for investigating the effect of stock liquidity on corporate cash holdings comes from two strands of the theoretical literature. The first idea relates to the theory of positive feedback from stock prices to cash flows developed by Subrahmanyam and Titman (2001). The view that stock prices can affect fundamentals is also central in Hirshleifer, Subrahmanyam, and Titman's (2006) theory of stock price feedback and sentiment traders.

As discussed by these authors as well as by Titman (1984), lower stock prices can, for example, reduce customers' perceptions of firms' products and services and also firms' ability to retain or attract key personnel. With respect to empirical evidence, Hortacsu, Matvos, Syverson, and Venkataraman (2013) find that at increase in a car manufacturer's CDS spreads decreases the prices of its cars in wholesale markets. Subrahmanyam and Titman (2001) show that positive feedback can affect cash flows from assets-in-place as well as the value of future growth opportunities and that this can give rise to positive feedback loops, or cascades, between stock prices and fundamentals. Our idea is that corporations therefore have an incentive to hold cash to nip negative cascades in the bud, or to attempt to stimulate positive cascades if the opportunity should arise, for example by buying their own stock in the market. Because it takes more cash to move the price of liquid stocks, under the cascade hypothesis we expect a corporation's cash holdings to be increasing in the liquidity of its stock.

Related to this, Goldstein, Ozdenoren, and Yuan (2013) develop a model where the feedback mechanism works through the cost and availability of capital. These authors also argue that negative cascades ("trading frenzies") are more likely to occur in the first place for more liquid stocks. This reinforces the need for corporations with more liquid stock to hold more cash, as ammunition to ward off negative cascades.

The second theoretical idea relates to result from the market microstructure literature that the liquidity of a stock is inversely related to the degree of information asymmetries between investors and market makers (Glosten and Milgrom, 1985; Kyle, 1985). Using the logic in Grossman and Stiglitz (1980), we would expect a relatively high degree of information asymmetry to be associated with relatively large costs of information acquisition. Thus, we would expect this to be associated with a relatively large degree of information asymmetry between insiders and investors, as well, implying a relatively large adverse selection problem with respect to outside financing (Myers and Majluf, 1984). In other words, firms with less liquid stocks are more "financially constrained;" they face larger costs of external financing, and would therefore be expected to hold more cash. This is the opposite prediction of what we get from the cascade hypothesis. We seek to see which of these two potential effects dominate in the data.

These two theoretical ideas also involve differing perspectives on the role of cash with respect to growth opportunities and investments. Subrahmanyam and Titman (2001) show that cascades have bigger impact for firms with larger intrinsic growth opportunities. The cascade perspective is thus essentially that firms hold cash to protect or enhance (the value of) growth opportunities. The information/financial constraint perspective represents the traditional precautionary motive emphasized in the literature that holding cash protects the ability to invest, or existing shareholders' share of the NPV from new investments (Myers and Majluf, 1984). Hence, under the cascade hypothesis, we would expect the cash ratio sensitivity to stock liquidity to be higher for firms with higher growth opportunities; whereas, under the information/financial constraints hypothesis, we would expect the opposite. In either case, we expect to see firms with higher growth opportunities holding more cash, consistent with what is already documented in the literature (Opler, Pinkowitz, Stulz, and Williamson, 1999; Bates, Kahle, and Stulz, 2009).

We employ two standard measures of stock liquidity, namely Amihud's (2002) *ILLIQ* measure of price impact and the relative effective bid-ask spread (Chordia, Roll, and Subrahmanyam, 2001). *ILLIQ* has the advantage of being computable for all CRSP stocks. The relative effective bid-ask spread is calculated using the NYSE's TAQ database, which limits both the available time period and the set of stocks. However, our findings do not depend in a significant way on which liquidity measure is used. To control for information flow, in some tests we also use Roll's (1988) price-nonsynchronicity measure (as modified by Durnev, Morck, and Yeung, 2004). This measure is typically interpreted as capturing the private information content of prices (Morck, Yeung, and Yu, 2000; Durnev, Morck, and Yeung, 2004; Bushman, Piotroski, and Smith, 2002). The qualitative findings on the effects on cash holdings of stock liquidity do not depend on whether the price-nonsynchronicity measure is included in the regressions.

The price-nonsynchronicity measure is interesting to consider also because there is evidence that increased price-nonsynchronicity is associated with more efficient investments (Durnev, Morck, and Yeung, 2004), the idea being that high price-nonsynchronicity implies more informative stock prices which, in turn, help managers make more efficient investment decisions, as per the theories of Dow and Gorton (1997) and Subrahmanyam

and Titman (1999). Empirical support for this view is also provided by, for example, Chen, Goldstein, and Jiang (2007) and Bakke and Whited (2010). In addition, Fresard (2012) provides evidence that price-nonsynchronicity has an impact on cash savings (yearly changes in cash holdings). With respect to cash holdings, as we study in this paper, we find that stock liquidity has a more consistently statistically significant effect than price-nonsynchronicity.

We carry out several pieces of analyses. First, we regress firms' cash ratios on measures of lagged stock liquidity and a host of control variables, including price-nonsynchronicity and all those used by Bates, Kahle, and Stulz (2009). Cash holdings and other accounting data are sourced from COMPUSTAT, with CRSP and TAQ being used to calculate measures of stock liquidity. We also use Thomson Reuters (13f) to obtain measures of institutional ownership, as this may affect the propensity of cascades in a stock, and IBES for analyst coverage data. These first regressions are run over several different time periods, determined by the availability of the liquidity and control variables. Regardless of which time period,- stock liquidity measure,- or set of control variables we use, we find that firms with more liquid stocks hold more cash as a fraction of their assets. This is consistent with the cascade perspective.

Second, we examine the impact of stock liquidity on cash holdings for firms with different growth opportunities, as measured by market-to-book ratios and R&D expenditures. Again, consistent with the cascades perspective, we find that the cash ratio sensitivity to stock liquidity is higher for firms with higher growth opportunities (higher market-to-book ratios or R&D expenditures). Endogeneity is addressed in both the first and second set of regressions by using lagged values of the liquidity measures.

Third, to further address endogeneity concerns, we follow Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009) by using the introduction of tick-size decimalization on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ in 2001 as a natural experiment where liquidity is exogenously shocked. Here, we capture liquidity by the average number of trades per day. We carry out standard difference-in-difference tests, including the use of placebo years. Our findings support the hypothesis that higher stock liquidity leads to an increase in cash holdings.

Fourth, to address two-way causality, we run two-stage least squares on a system of simultaneous equations that allows for cash ratios and stock liquidity to be jointly determined. We find support for joint causality. Increased cash holdings lead to higher stock liquidity, as argued by Gopalan, Kadan, and Pevzner (2012), but higher stock liquidity also leads to higher cash holdings, consistent with the idea that firms hold cash to fend off negative cascades or stimulate positive ones.

The rest of the paper is organized as follows: Section 2 describes the data and the variables. The control variables are mostly drawn from the extant literature on corporate cash holdings, as discussed in Section 2. Section 3 contains the first and second set of regression results. Section 4 contains the analysis using the introduction of decimalization as a natural experiment of an exogenous liquidity shock. Section 5 looks at joint causality, and Section 6 concludes.

2 Data, variables, and descriptive statistics

The main datasource is the CRSP/COMPUSTAT Merged (CCM) database, 1963-2010 inclusive. We exclude financial firms (SIC code between 6000 and 6999) and utilities (SIC code between 4900 and 4999). We only keep firm-years with positive total assets, positive sales, and with a ratio of total debt (long term debt plus current liabilities) to total assets that is between 0 and 1. We only include common stocks traded on NYSE, AMEX and NASDAQ. To be included, within a fiscal year stocks need to trade on no less than 100 days, not change exchanges, and have prices not exceeding US$ 999 per share. Some firms may have multiple classes of common shares. In the case of two classes of common shares for a given firm-year, we take the one with the higher turnover. We delete firm-years with more than two classes of common shares. In total, over the 1963-2010 period, this leaves us with 92,415 firm-year observations. Because our liquidity measures are calculated on an annual basis and we use them with a lag of one year in most regressions, the effective sample period is 1964-2010, which yields a sample size of 92,169 firm-years. The variables we use and supplementary databases are described below.

2.1 Liquidity measures

In our main analysis, we use two stock liquidity measures, one using low frequency and one using high frequency data. The low frequency measure is Amihud's (2002) *ILLIQ*,[1] originally defined as

$$ILLIQ\_\text{Amihud}_{i,t} = \frac{1}{N_i}\sum_{d=1}^{N_i}\frac{|r_{i,t,d}|}{DVol_{i,t,d}},$$

where $r_{i,t,d}$ is stock i's rate of return on day d in year t, $DVol_{i,t,d}$ is the corresponding dollar volume (in USD millions), and N_i is the number of trading days of stock i in year t. Returns and volume data are from CRSP. Atkins and Dyl (1997) and Anderson and Dyl (2007) note that the dealer structure on NASDAQ leads to a double counting problem of trading volume. As suggested by Atkins and Dyl (1997) and Nagel (2005), we address this double counting problem by dividing the reported dollar volume of NASDAQ stocks by two. Furthermore, following Nyborg and Östberg (2011), we exclude daily CRSP observations with positive volume but no recorded closing price on either day d or $d-1$ and a zero return on day d, as this is highly suggestive of stale prices and spurious volume. Finally, following Acharya and Pedersen (2005), we adjust Amihud's *ILLIQ* by stock price "inflation," cap it to reduce the impact of extreme values, and bound it away from zero, leaving us with the following final measure:

$$ILLIQ_{i,t} = \min\left(0.25 + 0.30 \times ILLIQ\_\text{Amihud}_{i,t} \times P_{t-1}^{M},\ 30.00\right), \tag{1}$$

where P_{t-1}^{M} is the ratio of the capitalizations of the market portfolio at the end of fiscal year $t-1$ and July 1962. To deal with endogeneity concerns, in our regressions we always used lagged values of our liquidity measures.

The high frequency liquidity measure, which we use TAQ to compute, is the relative effective bid-ask spread (Chordia, Roll, and Subrahmanyam 2001, Fang, Noe, and Tice 2009). The effective spread is defined as the difference between the execution price and the mid-point of the prevailing bid-ask quote. The relative effective bid-ask spread is the effective spread divided by the mid-point of the prevailing bid-ask quote.

[1] In their tests of liquidity measures, Goyenko, Holden, and Trzcinka (2009) find that *ILLIQ* is the best performing low frequency measure.

Using TAQ, we proceed in the usual way to compute the relative effective bid ask spread: Quotes established before the opening of the market or after the close of the market are excluded. Quotes are also discarded if the offer price is lower than the bid price. The trade record is excluded if it does not have a positive price or trading size. The Lee and Ready (1991) algorithm is then used to match trades and quotes: for a trade between 1993 and 1998, the five-second rule is used; for a trade between 1999 and 2010, the trade is matched to the first quote before the trade. The same matching methodology is used by Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009). To eliminate potential errors in trades and quotes, following Chordia, Roll, and Subrahmanyam (2001), after the matching process, we exclude observations which satisfy the following four conditions:

1. Quoted spread $>$ \$5;
2. Effective spread/Quoted spread > 4.0;
3. Relative effective spread/Relative quoted spread > 4.0;
4. Quoted spread/Transaction price > 0.4,

where Quoted spread is the difference between the prevailing quoted bid and ask, and the Relative quoted spread is Quoted spread divided by the mid-point of the corresponding quoted bid and ask.

The daily relative effective bid-ask spread is calculated by taking the arithmetic mean of the transaction-level relative effective bid-ask spreads over the day. The annual relative effective bid-ask spread is the average of daily relative effective bid-ask spreads within the relevant fiscal year. Following Fang, Noe, and Tice (2009), we use the logarithm of the annual relative effective bid-ask spread in our analysis, which we denote by *Log_resprd*.

TAQ data is available from 1993. Because we used lagged measures of liquidity in most regressions, this means that those regressions have sample periods from 1994-2010.

2.2 Additional variables, datasources, and descriptive statistics

Cash holdings are measured for each firm-year by the Cash Ratio, i.e. cash and short-term investment (CHE) over the total book assets (AT), where the COMPUSTAT variable names are in parentheses. Because our main objective is to investigate the impact of stock liquidity on corporate cash holdings, the dependent variable in our regressions is the Cash Ratio and the main regressors are measures of stock liquidity. Control variables are discussed below, with details provided in the Appendix.

The control variables can be divided into three subsets. First, we follow Bates, Kahle, and Stulz (2009) by including Firm Size, MTB (market-to-book ratio), Leverage, Net Working Capital, Net Equity Issuance, Net Debt Issuance, Dividend Dummy, R&D, Capital Expenditure, Acquisition, Cash Flow, Industry Sigma, and IPO2-IPO5 (dummies for years after an IPO). Some of these variables, such as Firm Size and Dividend Dummy, are also often used in the literature as measures of financial constraints. Like the Cash Ratio, dollar denominated variables such as R&D are normalized by total assets (see the Appendix). Not all of these COMPUSTAT variables are available over the whole 1963-2010 period. Net Equity Issuance, Net Debt Issuance, and Acquisition are only available from 1971. Some regressions are therefore run over the period 1971-2010.

Second, we use some controls that are found to be associated with cash holdings by other authors. In particular, we use Analyst Coverage (Chang, 2012), Inst. Turnover (institutional turnover) (Brown, Chen, and Shekhar, 2011), and Price-nonsynchronicity (Fresard, 2012). Analyst coverage data are from IBES, which is available from 1976. The data on institutional investors' stock holdings are from Thomson Reuters (13f), which is available from 1980. Thus, we run some regressions over a sample period from 1980-2010. We also use institutional ownership, as in Brown et. al, but we break it up into two parts: Inst. Own ($> 5\%$) and Inst. Own ($< 5\%$). Inst. Own ($> 5\%$) is the proportion of shares owned by institutional investors individually holding more than 5% of shares outstanding. We use it as a proxy for corporate governance, as in Dittmar and Mahrt-Smith (2007). Better corporate governance can increase the value of cash holdings and thereby encourage more cash holdings (Dittmar and Mahrt-Smith 2007, Harford, Mansi, and Maxwell 2008).

Inst. Own ($< 5\%$) is the remaining institutional ownership. Smaller holdings may be less costly to unload, potentially making the stock price more vulnerable to negative news. We expect the institutional investor turnover and both institutional ownership variables to have positive impact on cash holdings.[2]

Price-nonsynchronicity is defined as $\ln[(1 - R^2_{i,t})/R^2_{i,t}]$ following Durnev, Morck and Yeung (2004), where $R^2_{i,t}$ is estimated for each stock i for each year from the regression $r_{i,j,w} = \alpha_i + \beta_{i,m} r_{m,w} + \beta_{i,j} r_{j,w} + \varepsilon_{i,w}$. $r_{i,j,w}$ is the weekly stock return of firm i in industry j and week w, $r_{m,w}$ is the weekly value-weighted market return, and $r_{j,w}$ is the weekly value-weighted industry return, where industries are classified by three-digit SIC codes. As discussed by Roll (1988) and Durnev, Morck and Yeung (2004), Price-nonsynchronicity can be viewed as a measure of the quantity of private information flowing into stock prices. We include this here as a control because, as discussed in the Introduction, stock liquidity may reflect information asymmetries among investors and market makers. Furthermore, Fresard (2012) provides some evidence that price-nonsynchronicity affects cash savings (changes in cash holdings), which we discuss in more detail below in Subsection 3.2.

Third, we introduce two new control variables, namely Firm Age and Equity Beta. Firm Age is expected to have a negative effect on cash holdings because young firms tend to have relatively weak connections with corporate stakeholders, such as customers, suppliers, employees, and investors. Thus, negative cascades are more likely to take place for young firms (Subrahmanyam and Titman, 2001; Almanzan, Suarez, and Titman, 2009). Equity Beta can be regarded as a proxy for the systematic risk of a business. We expect it to have a positive impact on cash holdings, for precautionary reasons.

The sample is winsorized as follows. R&D, Acquisition, Capital Expenditure, and Industry Sigma are winsorized on both sides at 1%. Equity Beta is winsorized on both sides at 0.5%. Net Working Capital and Cash Flow are winsorized from the bottom at 1% and MTB is winsorized from the top at 1%.

Insert Table 1 here.

[2]Quarterly institutional investor data are from Thomson Reuters 13f. Relevant variables are calculated for each quarter and then averaged across the fiscal year to generate the annual measure.

Table 1 displays descriptive statistics of all the variables. Statistics on the main variables, Cash Ratio and *ILLIQ*, are provided for four sample periods; 1964-2010, 1971-2010, 1980-2010, and 1994-2010. The average Cash Ratio ranges from 0.14 (1964-2010) to 0.18 (1994-2010), reflecting the upward drift in cash holdings documented by Bates, Kahle, and Stulz (2009). Over the same periods, average *ILLIQ* is 7.84 and 8.8, respectively. Statistics for the other variables are provided for the full period for which data is available and as indicated in the table.

2.3 Correlations and orthogonalization

Table 2 provides the correlation matrix of all variables. The correlation between the two liquidity measures and the Cash Ratio is 0.02, showing that unconditionally, the relation between cash holdings and stock liquidity is weak. The variables with the largest positive correlations with the Cash Ratio are R&D (0.48), Industry Sigma (0.38), and MTB (0.37), which is consistent with the notions that firms hold cash to invest and for precautionary reasons.

Insert Table 2 here.

Firm size is also a key determinant of cash holdings (Opler, Pinkowitz, Stulz, and Williamson, 1999; Bates, Kahle and Stulz, 2009), but is highly correlated with some of the other regressors, leading to a potential collinearity problem when we come to run regressions. Its correlations with *ILLIQ*, Log_resprd, Price-nonsynchronicity, Analyst Coverage, and Inst. Own ($< 5\%$), are -0.64, -0.81, -0.57, 0.68, and 0.73, respectively. To address this, for each year t, we orthogonalize these variables with respect to size by running OLS as follows:

$$X_{i,t} = \gamma_0 + \gamma_1 \text{Firm Size}_{i,t} + \eta_{i,t} \tag{2}$$

where X is one of the mentioned variables, i is a firm. In the analysis below, we replace the original variable, X, by the residual η from (2). We denote the size-orthogonalized variable X by X_res; e.g., *ILLIQ* becomes *ILLIQ_res* and Price-nonsynchronicity becomes Price-nonsynch_res.

3 Regression results

This section contains the first two sets of results on the relation between stock liquidity and cash holdings. We first run a set of regressions of cash ratios on stock liquidity, captured by the size-orthogonalized liquidity measure *ILLIQ_res*, Price-nonsynch_res, and the other control variables discussed in Section 2. These regressions are run over different time periods that depend on the availability of the control variables. To further examine the cascade versus information/financial constraint hypothesis with respect to the effect of stock liquidity on cash holdings, we run a second set of regressions using both measures of liquidity, *ILLIQ_res* and *Log_resprd_res*, to study the cash ratio sensitivity to stock liquidity as a function of growth opportunities. We capture growth opportunities by two measures, namely MTB and R&D expenditures.

3.1 Baseline regressions of cash holdings on stock liquidity

To examine the relation between cash holdings and stock liquidity, we initially use the following specification over firm-years (i, t)

$$\text{Cash Ratio}_{i,t} = \beta_0 + \beta_1 ILLIQ\_res_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t}, \tag{3}$$

where $\mathbf{Z}$ is a vector of control variables and $\mathbf{\Gamma}$ the corresponding vector of regression coefficients. The controls are as discussed in Section 2. Not all of these are available over the whole sample period. We therefore run (3) over three time periods, namely: 1964-2010 (the full sample period), 1971-2010 (Net Equity Issuance, Net Debt Issuance, and Acquisition are available from 1971), and 1980-2010 (analyst coverage and institutional holding data are available from 1976 and 1980, respectively). In this subsection, we use only *ILLIQ_res* to measure size-orthogonalized stock liquidity, because TAQ, which we use to calculate the effective bid-ask spread, is not available before 1993. Since one of the competing hypotheses we wish to examine is the information/financial constraint hypothesis of the effect of stock liquidity on cash holdings, we run two sets of regressions for each time period; one with and one without lagged Price-nonsynch_res as a control.

Insert Table 3 here.

Table 3 reports on the results from running (3) using the Fama-MacBeth procedure (t-statistics are calculated using Newey-West standard errors with two lags).[3] In all specifications and all time periods, the coefficient on $ILLIQ\_res_{i,t-1}$ is negative and statistically significantly at the 1% level. Since stock liquidity is decreasing in *ILLIQ*, this means that firms with more liquid stocks hold more cash. This is consistent with the cascade hypothesis. The coefficient ranges from -0.0015 (1980-2010 period) to -0.0025 (1964-2010 period). So, for example over the 1964-2010 period, a one standard deviation decrease in *ILLIQ_res* increases the cash ratio by 2.02%. The economic significance of this can be seen in light of the fact that the average cash holding across firm-year's over this period is 14% of assets, with a standard deviation of 18%. Thus, the 2.02% increase represents an increase of approximately 15% of an average firm's cash holdings.

The coefficient on Price-nonsynch_res is statistically significantly negative, which one can interpret as saying that the more informative is the stock price, the less cash do firms hold, if one accepts the interpretation of Price-nonsynchronicity as a measure of the informativeness of stock prices. This appears to be in conflict with the negative coefficient on *ILLIQ_res*, if one views more liquid stocks as having more informative prices. It is possible that Price-nonsynchronicity and *ILLIQ* capture different elements of private information and price informativeness. We will come back to the impact of Price-nonsynch_res in the next subsection, when we also include interaction variables and can assess the robustness of the initial findings in this subsection.

Insert Table 4 here.

The coefficients on the control variables and their statistical significance is consistent with what is documented in the extant literature, as summarized in Table 4. For example, we see that large firms hold less cash as a fraction of their assets, which is consistent with their being less financially constrained, for example due to smaller information asymmetry problems. With respect to the new control variables introduced in this paper, the

[3]We have also run (3) as a panel regression with industry and year fixed effects and with standard errors clustered on firm. The results are qualitatively the same. The regressions have also been run during the 1994-2010 sample period using both *ILLIQ_res* and *Log_resprd_res*. Again the results are qualitatively same, except that Price-nonsynch_res is now not significant at conventional levels. Details are available from the authors upon request. We report on regressions using *Log_resprd_res* in the next subsection.

coefficients on Equity Beta and Firm Age are positive and negative, respectively. This is in line with the view that firms with higher equity betas and those that are younger are more financially constrained. The coefficients on Analyst Coverage is positive, consistent with the cascade hypothesis, as more analyst coverage brings more attention to the firm. Inst. Ownership ($> 5\%$) also has a statistically significant positive coefficient, consistent with the view that it improves corporate governance and thus increases the value of cash holdings, which in turn leads to larger cash holdings. The coefficient on Inst. Ownership ($< 5\%$) is also statistically significantly positive, which we interpret as consistent with the cascade hypothesis as discussed in Section 2.

3.2 Stock liquidity and growth opportunities

In this subsection, we investigate how the cash ratio sensitivity to stock liquidity varies with growth opportunities. Under the cascade view, more potential growth makes firm value more sensitive to cascades, implying that cash holdings should be increasing in stock liquidity as growth opportunities increase. The information/financial constraint view leads to the opposite prediction. We measure growth opportunities by MTB (market-to-book) and R&D expenditures (normalized by assets).

This subsection expands on the analysis in the previous subsection in the following ways. First, we use both (size-orthogonalized) measures of stock liquidity, *ILLIQ_res* and *Log_resprd_res*. Second, to study how the cash ratio sensitivity to stock liquidity varies with growth opportunities, we include variables that interact our measures of growth opportunities with our liquidity measures. Third, we also interact the growth opportunity measures with Price-nonsynch_res and Firm Size.

Table 5 reports on the results from running panel regressions, with industry and year fixed effects and standard errors clustered on firm, as well as Fama-MacBeth regressions. The sample period is 1994-2010, which matches the availability of TAQ data to calculate *Log_resprd_res* (we used lagged measures of stock liquidity). Growth opportunities are captured by MTB in Panel A and by R&D in Panel B. For each procedure (fixed effects or Fama-MacBeth), we run four specifications, two each for each liquidity measure. The first specification interacts the growth opportunity measure with the stock liquidity measure

only. The second specification also interacts growth opportunities with Price-nonsynch_res and Firm Size. Thus, we run sixteen specifications in total.

Insert Table 5 here.

We see in Table 5 that in thirteen (three) of the sixteen specifications, the coefficient on the stock liquidity measure is negative and statistically significant at the 1% (5%) level. Thus, the result from the previous subsection that the cash ratio is increasing in stock liquidity is shown to be robust to including interaction terms and to using *Log_resprd_res* instead of *ILLIQ_res*. Furthermore, and more specific to our main subject of interest in this subsection, in fourteen (one) of the sixteen specifications, the *liquidity measure* × *growth opportunity measure* is negative and statistically significant at the 1% (5%) level. Given that we retain all control variables and have size-orthogonalized the two liquidity measures, this is strong evidence that the cash ratio is increasingly sensitive to stock liquidity as growth opportunities increase. The more growth opportunities a firm has, the more cash does it hold (as a fraction of assets) as its stock liquidity increases. This is consistent with the cascade perspective, whereby holding cash serves to protect growth opportunities from negative cascades or enhance growth opportunities from positive ones.

The results on price-nonsynchronicity are weak. Across all sixteen specifications, there are only two instances where the coefficient on Price-nonsynch_res is statistically significant at conventional levels, and in both cases it is at the 10% level. In these two cases, the coefficient is negative as before. In Panel A, Price-nonsynch_res is interacted with our first growth opportunity measure, MTB, in four specifications. The coefficient is positive in all four specifications, but only statistically significant in one specification (when using *Log_resprd_res* as the liquidity measure under the Fama-MacBeth procedure). When interacting Price-nonsynch_res with the other growth opportunity measure, R&D, in Panel B, the coefficient is negative and statistically significant in three out of four cases. The results on price-nonsynchronicity are thus substantially weaker and less consistent than the results on stock liquidity.

Our results on price-nonsynchronicity stand in contrast to those of Fresard (2012), who finds that when regressing cash savings on MTB, MTB × Price-nonsynchronicity, firm size,

and other controls, the coefficient on the interaction term is positive and statistically significant. While we study cash holdings and Fresard studies cash savings, it may nevertheless be useful to briefly discuss our seemingly different results. We have re-examined Fresard's regressions in his Table IV (details available upon request) and found that in his regressions, if we include an additional interaction term, MTB $\times$ Size, the coefficient on MTB $\times$ Price-nonsynchronicity becomes insignificant. Recall, however, from above that the correlation between Firm Size and Price-nonsynchronicity is large in absolute value, so including these in the same regression as Fresard does is problematic. If instead of including MTB $\times$ Size in Fresard's regressions, we simply replace Price-nonsynchronicity by Price-nonsynch_res, we find that the coefficient on the interaction term is insignificant (details available from the authors upon request). This parallels our findings on cash holdings (rather than savings) in Table 5, Panel A.

Our finding that the cash ratio sensitivity to Price-nonsynch_res falls as R&D expenditures increase can be interpreted in light of a standard Myers and Majluf (1984) style argument, predicated on the idea that Price-nonsynchronicity measures the informativeness of prices. First, when the flow of private information into prices is larger, this may also involve a lower degree of information asymmetries between managers and outsiders. In turn, this reduces the costs of external financing and therefore also the importance of holding financial slack (cash). This is especially relevant for firms with large R&D expenditures because, in the first instance, the R&D needs to be financed and, in the second, so do the opportunities that the R&D lead to. Indeed, the regression coefficients in Table 5 on R&D itself is positive. Our finding can therefore be interpreted as follows: While cash holdings increase in R&D, the effect is reduced for firms with more informative stock prices because this is associated with less costly external financing.

It may seem surprising that we do not find a similar effect for the market-to-book ratio. An explanation may be that information asymmetries between investors and managers relate mostly to the likelihood of success of R&D and new technologies rather than to the growth of existing lines of business. This may explain why price-nonsynchronicity works better when interacted with R&D than with MTB, as the latter measure also captures projected growth from expanding current lines of business.

With respect to our other controls, we note that in all specifications, the coefficient on the growth opportunity × Firm Size interaction variable is positive, showing that larger firms hold relatively more cash as their growth opportunities increase. This may reflect that more is at stake for larger firms. All other controls are in line with the findings in the previous subsection and the extant literature, as summarized above in Table 4.

4 Endogeneity: Decimalization test

In the previous section, we dealt with the potential endogeneity of stock liquidity by lagging it. Orthogonalizing the liquidity measures by size, which we did because of the high correlation coefficient with Firm Size, also helps with respect to endogeneity as it reduces persistence in the measure of stock liquidity we use in the regressions. In this section, we take an alternative tack. We use the introduction of decimalization in stock exchanges as a natural experiment where stock liquidity is exogenously shocked. Specifically, on January 29, 2001, the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) changed the minimal tick size from 1/16th of a dollar (6.25 cents) to 1 cent. NASDAQ decimalized on April 9, 2001.[4]

The extant literature shows that the introduction of tick size decimalization affected stock liquidity heterogeneously. Bessembinder (2003) and Furfine (2003) find that the quoted bid-ask spreads and price impact declined more for more actively traded stocks. Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009) have used this exogenous and asymmetric effect on stock liquidity to study the effect of stock liquidity on market efficiency and firm performance, respectively. Under the cascade hypothesis, we expect that more actively traded stocks, which experienced a bigger improvement in their liquidity as a result of decimalization, should have a larger increase in cash holdings than less liquid stocks.

We measure how actively a stock is traded by the total number of trades (*Num_trades*) in a fiscal year. This is extracted from TAQ. The test sample includes observations in

[4]Pilot programs were carried out before trading on all listed stocks were decimalized. For example, at the NYSE, decimalization was introduced for 159 securities between August and December in 2000. At the NASDAQ, decimalization was introduced for 211 securities in March 2001.

the year before and the year after the introduction of decimalization. This relatively long window around the introduction of decimalization follows Fang, Noe, and Tice (2009) and provides time for the change in liquidity to affect a firm's cash holdings. We divide the test sample into the 50% most active and the 50% least active stocks, based on the number of trades in the year before the introduction of decimalization.

We use the following specification:

$$\Delta\text{Cash ratio}_i = \beta_0 + \beta_1 \text{Dummy\_Active}_i + \mathbf{\Gamma}'(\Delta\mathbf{Z}_i) + \varepsilon_i, \tag{4}$$

where ΔCash ratio$_i$ is the change in the cash ratio for firm i from the fiscal year prior to decimalization (2000) to the year after (2002), *Dummy_Active* is an indicator variable that equals 1 for the 50% most active stocks and 0 for the least active stocks, $\Delta\mathbf{Z}_i$ is a vector of changes in the control variables for firm i from the year prior to decimalization to the year after, and $\mathbf{\Gamma}$ is the corresponding vector of regression coefficients. The control variables include all those in Table 3 and IPO1, which is a dummy for the first year after an IPO.[5] The regression (4) is run using OLS. Reported t-values are calculated using White's (1980) correction for heteroskedasticity.

Insert Table 6 here.

The regression results are shown in Table 6, Panel A. The coefficient on Dummy_Active is positive and statistically significant at the 1% level. In other words, more active stocks, whose liquidity improved the most as a result of decimalization, experienced a larger increase in cash holdings after decimalization than less active stocks. This is consistent with the cascade hypothesis and the results in Section 3.

As a robustness check to our decimalization test, we carry out a placebo test where we re-run (4) for each year from 1996 to 2006 (i.e. where 1996, for example, takes the place of 2001 in the original test). As seen in Panel B of Table 6, the coefficient on ΔCash Ratio is significantly different from zero only for 2001, the year decimalization was introduced. Thus, our findings in this section support the hypothesis that higher stock liquidity leads

[5]Unlike the regressions in Table 3, no lagged variable is used in the current test, allowing us to include IPO1 among the regressors.

to more cash holdings. It is consistent with the cascade hypothesis, but hard to reconcile with the financial constraint hypothesis with respect to stock liquidity.

5 Joint causality: Simultaneous equation system

In this section, we use a simultaneous equation system to investigate two-way causality between stock liquidity and corporate cash holdings. Because of the availability of all variables, we focus on the 1994-2010 period. The specification of the linear equation system is as follows:

$$\text{Cash Ratio}_{i,t} = \alpha_0 + \alpha_1 Liq\_res_{i,t} + \sum_{k=2}^{K} \alpha_k Z_{k,i,t-1} + \varepsilon_{i,t} \quad (5)$$

$$Liq\_res_{i,t} = \beta_0 + \beta_1 \text{Cash Ratio}_{i,t} + \sum_{l=2}^{L} \beta_l X_{l,i,t-1} + \eta_{i,t} \quad (6)$$

where *Liq* is *ILLIQ_res* or *Log_resprd_res*. $Z_{k,i,t-1}$ represent lagged controls in the Cash Ratio equation, (5). These include the same variables as in our baseline regression in Table 3 (column 6), except that we now use lagged values for all controls, as well as dummies for the 48 Fama-French industry categories. $X_{l,i,t-1}$ are the control variables in the stock liquidity regression, (6).

Our choice of controls in the liquidity equation draws on the extant literature. As in the literature, we use stock characteristics, firm characteristics, and institutional related variables. In particular, we use the following stock characteristic variables: Market Capitalization, Stock Price, and Return Volatility, Equity Beta (Heflin and Shaw, 2000; Loughran and Stulz, 2005; Chordia, Huh, Subruhmanyam, 2007; Agarwal, 2007; Rubin, 2007; Brockman, Chung, and Yan, 2009). With respect to firm characteristics, we use MTB, Firm Age, and Leverage (Chordia, Huh, and Subrahmanyam, 2007) and R&D and Cash Flow (Agarwal, 2007). Motivated by the investor recognition idea of Merton (1987), we also use IPO year dummies and Acquisition, as IPOs and acquisitions may attract investor attention, which in turn may affect trading activity and stock liquidity. With respect to institutional related variables, we use Analyst Coverage (Chordia, Huh, and Subrahmanyam, 2007), institutional turnover (Agarwal, 2007), and institutional owner-

ship (Heflin and Shaw, 2000; Agarwal, 2007; and Brockman, Chung, and Yan, 2009), which we break up into Inst. Own ($> 5\%$) and Inst. Own ($< 5\%$) as before. The new variables we use are thus IPO year dummies, Acquisition, and Inst. Own ($< 5\%$). The controls in (6), as in (5), also include dummies for the 48 Fama-French industry categories.

The two equation system, (5) and (6), is estimated by the Fama-MacBeth procedure, using two-stage least squares (2SLS) for each yearly cross-section. In particular, for each year t, using OLS we regress *Liq_res* (Cash Ratio) on all controls from both equations and obtain the fitted values $\widehat{Liq\_res}$ ($\widehat{\text{Cash Ratio}}$), which we then use in the Cash Ratio (*Liq_res*) regression in place of *Liq_res* (Cash Ratio). The estimated coefficients are then averaged over all years. t values are calculated using Newey and West (1987) standard errors with two lags. This is the same procedure used by Chordia, Huh, and Subrahmanyam (2007) in their examination of trading activity and analyst coverage.

Insert Table 7 here.

Table 7, Panel A reports on the results for the Cash Ratio equation. The first column is based on *Log_resprd_res* as the liquidity measure (with t-statistics in the second column), while the third column is based on *ILLIQ_res* as the liquidity measure (t-statistics in the fourth column). The results confirm our findings in Tables 3 and 5 that cash holdings are increasing in stock liquidity, regardless of which of the two measures of stock liquidity we use. Statistical significance is at the 1% level in either case. Panel B reports on the results for the liquidity equation. For either of the two liquidity measures, we see that stock liquidity is increasing in cash holdings. Statistical significance is at the 1% level in either case here as well. These results support the hypothesis that the causality between stock market liquidity and corporate cash holdings is bi-directional, as predicted by theory. In particular, this is consistent with (i) the theoretical idea that a higher level of corporate cash holdings reduces information asymmetries and therefore increases the liquidity of the corporation's stock, and (ii) the more liquid a corporation's stock is the more cash does it hold in order protect itself from negative cascades or to stimulate positive ones.

With respect to the control variables, we see in Panel A that their effect on cash holdings are largely the same as documented in Table 3. Given that all controls are lagged

in Table 7, this supports the robustness of the previous findings on their impact on cash holdings. When using *ILLIQ_res* as the liquidity measures, the most noteworthy difference is the coefficient on Inst. Own (< 5%), which goes from significantly positive (Table 3) to significantly negative (Table 7, Panel A). Industry Sigma is not significant in Table 7, unlike in Table 3, because the system in Table 7 is estimated with industry dummies. When industry dummies are not included, Industry Sigma is significantly positive (details available upon request).

Price-nonsynch_res has opposite signs when using *ILLIQ_res* (negative, significant at 1% level) as compared with *Log_resprd_res* (positive, significant at 10% level). Recall, however, from Table 5 that the effect of Price-nonsynch_res disappears when including interaction terms. Still, the change in sign here is reminiscent of the change in sign in Table 5 on the interaction variable of size and Price-nonsynch_res when using $R\&D$ rather than MTB as the growth opportunity measure. This suggests that more work may be needed in order to understand the price-nonsynchronicity measure better and that caution needs to be exercised when interpreting regression coefficients on Price-nonsynchronicity or Price-nonsynch_res.

Panel B summarizes our findings on the relation between stock liquidity and the control variables. With respect to the new variables we have introduced, we observe that Inst. Own (< 5%) has a statistically significantly negative effect (1% level) on both liquidity measures, i.e., a high fraction of relatively small institutional owners is positively associated with stock liquidity. Acquisition and R&D expenditures as a fraction of total assets also decrease *ILLIQ_res*, which is consistent, for example, with the view that acquisition activity and R&D intensity increases investor recognition and thus stock liquidity. With respect to the other variables, our resuls are broadly consistent with the extant literature. Stock liquidity, regardless of measure, is positively related to MTB, Stock Return, Equity Beta, and Analyst Coverage; and negatively related to Return Volatility and Leverage.

Our main point, here, however is that the results from our estimation of the simultaneous equation system of cash ratio and stock liquidity support the view that there is joint causality between cash holding and stock liquidity. A more liquid stock causes higher cash holdings, and vice versa.

6 Concluding remarks

We have provided evidence that supports the idea that there is a channel from the stock market to corporate financial policy. In particular, controlling for firm size and other standard variables in the cash holding literature, we have found that corporations with more liquid stock have higher cash ratios. Furthermore, the cash ratio sensitivity to stock liquidity is increasing in growth opportunities, measured by the market-to-book ratio or R&D expenditures normalized by total assets. This is consistent with the idea that the stock market channel with respect to cash holdings relates to positive feedback effects between stock markets and cash flows, along the lines of the theoretical contributions of Subrahmanyam and Titman (2001) or Goldstein, Ozdenoren, and Yuan (2013). Our analysis also provides support for the view that there is two-way causality between stock liquidity and cash holdings. Given our findings, an interesting avenue for future research would be to investigate whether market characteristics of a corporation's stock also affects other elements of its financial policy.

With respect to control variables, our analysis introduces two variables that have not previously been studied in the corporate cash literature. We find that the age of a firm is negatively associated with its cash ratio, consistent with the idea that younger firms face harder financial constraints. It is also consistent with the idea that cascades are more likely in younger firms, as they have less strong relations with customers and other stakeholders that can affect their value. With respect to the second new variable we introduce, we find that the beta of a firm's stock is positively related with its cash ratio, which is perhaps not surprising from a precautionary perspective.

One of the many control variables we use in this study is price-nonsynchronicity (Roll, 1988; Durnev, Morck, and Yeung, 2004). This variable is of separate interest, since it is widely used in the literature to gauge price informativeness. Because it is highly correlated with firm size, we size-orthogonalize it, as we do our stock liquidity measures. We find that firms with large R&D expenditures, which tend to hold more cash, reduce their cash holdings when price-nonsynchronicity becomes large. This is consistent with the view that more informative prices reduces the costs of external financing and thus reduces the

relative value of financial slack (Myers and Majluf, 1984). Interestingly, we do not find the same effect when measuring growth opportunities using the market-to-book ratio. This suggests that price-nonsynchronicity captures informativeness about growth opportunities from new products or technologies, rather than from existing lines of business.

In addition to our main finding that a higher level of stock liquidity leads to more cash holdings, and vice versa, we have also provided evidence on factors other than cash holdings that seem to affect stock liquidity. Our findings are broadly in line with the extant literature on this topic and supplement it by showing that stock liquidity is positively related to acquisition and R&D expenditures as well as the quantity of small institutional stakes in the stock. Gaining a deeper understanding of stock liquidity and its effects remains an important direction for future research.

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Appendix: Descriptions of variables

The names of variables in COMPUSTAT are shown in parentheses. *Used in equation (6) only.

Variable	Data source	Description
Acquisition	COMPUSTAT	The ratio of acquisition expenditures (AQC) relative to total book assets (AT).
Analyst Coverage	IBES	Take average of the number of estimates across months within a fiscal year. Then take logarithm of one plus the average. If a stock is not covered in IBES, set the Analyst Coverage to zero.
Cash Flow	COMPUSTAT	[EBITDA (OIBDP) − interest (XINT) − taxes (TXT) − common dividends (DVC)]/total assets (AT).
Capital Expenditure	COMPUSTAT	The ratio of capital expenditures (CAPX) to the book value of total assets (AT).
Cash Ratio	COMPUSTAT	The ratio of cash and short-term investment (CHE) to the book value of total assets (AT).
Dividend Dummy	COMPUSTAT	A dummy variable equal to one if a firm paid common dividend (DVC) in that year; zero otherwise.
Equity Beta	CRSP	Annual Scholes-Williams (1977) beta. Available from CRSP.
Firm Age	CRSP	Calculate the number of months since a stock first appears in CRSP. Then take logarithm of one plus the number of months.
Firm Size	COMPUSTAT	Logarithm of total assets, where the total assets are deflated to 1962 dollars.
Industry Sigma	COMPUSTAT	The industry (2-digit SIC codes) mean of firm level Cash Flow standard deviations (over 10 years, at least 3 firm-year observations required). Follows the definition in Bates, Kahle, and Stulz (2009).

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Variable	Data source	Description
ILLIQ	COMPUSTAT	Acharya and Pedersen's (2005) adjusted version of Amihud's (2002) original illiquidity measure. See equation (1) in the text.
Inst. Turnover	Thomson Reuters (13f)	First, calculate institutional churn ratio following Yan and Zhang (2009): $\text{Churn Ratio}_{k,t} = \frac{\min(\text{Churn\_buy}_{k,t}, \text{Churn\_sell}_{k,t})}{\sum_{i=1}^{N_k}(S_{k,i,t}P_{i,t} + S_{k,i,t-1}P_{i,t-1})/2}$, where N_k is the total number of stocks in the portfolio of institution k, $S_{k,i,t}$ is the number of shares of stock i held by institution k in quarter t, $P_{i,t}$ is the price of stock i in quarter t, $\text{Churn\_buy}_{k,t} = \sum_{i=1,\ S_{k,i,t}>S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\text{Churn\_sell}_{k,t} = \sum_{i=1,\ S_{k,i,t}\leq S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\Delta P_{i,t}$ is the change in price, $P_{i,t} - P_{i,t-1}$. Second, following Gaspar, Massa, and Matos (2005), Inst. Turnover is calculated as $\sum_{k\in\mathcal{S}} w_{i,k,t}\left(\frac{1}{4}\sum_{r=1}^{4}\text{Churn Ratio}_{k,t-r+1}\right)$, where $\mathcal{S}$ is the set of institutional shareholders of stock i, and $w_{i,k,t}$ is the weight of investor k in the total percentage held by institutional investors in year-quarter t. Then an annual Inst. Turnover is calculated as the average across a year.

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Variable	Data source	Description
Inst. Own (< 5%)	Thomson Reuters (13f)	Total proportion of shares outstanding held by institutional investors with less than 5% of shares outstanding each.
Inst. Own (> 5%)	Thomson Reuters (13f)	Total proportion of shares outstanding held by institutional investors with more than 5% of shares outstanding each.
IPO1-IPO5	CRSP	Dummy variables equal to one if the firm went public 1 to 5 years ago respectively.
Leverage	COMPUSTAT	Total debt divided by total assets (AT), where total debt is long-term debt (DLTT) plus debt in current liabilities (DLC).
Log_resprd	TAQ	Logarithm of relative effective bid-ask spread. Relative effective bid-ask spread is the difference between the execution price and the mid-point of the prevailing bid-ask quote divided by the mid-point of the prevailing bid-ask quote.
Market Capitalization - log*	COMPUSTAT	Logarithm of market capitalization, which is computed as PRCC_F×CSHO, and then adjusted for inflation based on CPI in 1962.
MTB	COMPUSTAT	[Book value of total assets (AT) − book value of equity (CEQ) + market value of equity (PRCC_F× CSHO)]/book value of total assets (AT).
Net Debt Issuance	COMPUSTAT	[Annual total debt issuance (DLTIS) − debt retirement (DLTR)]/the book value of total assets (AT).
Net Equity Issuance	COMPUSTAT	[Equity sales (SSTK)− equity purchases (PRSTKC)]/the book value of total assets (AT).
Net Working Capital	COMPUSTAT	[Net working capital (WCAP) − cash and short-term investment (CHE)]/total assets (AT)

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Variable	Data source	Description
Price-nonsynchronicity	CRSP	Firm specific stock return variation of firm i in year t. Specifically, it is $\ln[(1-R^2_{i,t})/R^2_{i,t}]$, where $R^2_{i,t}$ is estimated each year for the regression $r_{i,j,w} = \alpha_i + \beta_{i,m} r_{m,w} + \beta_{i,j} r_{j,w} + \varepsilon_{i,w}$. $r_{i,j,w}$ is the weekly stock return of firm i in industry j week w, $r_{m,w}$ is the weekly market return, $r_{j,w}$ is the weekly industry (3-digit SIC code) return. Market and industry returns are value-weighted averages. Defined as in Durnev et al. (2004).
R&D	COMPUSTAT	The ratio of research and development expense (XRD) to total assets (AT). If XRD is missing then set R&D to zero.
Stock Price - log*	CRSP	Logarithm of stock price. Adjusted to 1962 dollars by the CPI.
Stock Return Volatility*	CRSP	Standard deviation of daily stock return within a fiscal year.

Table 1
Descriptive statistics

Panel A displays summary statistics of the main variables. Variable names followed by a year means the statistics are calculated using data starting from that year and ending in 2010. E.g., *CashRatio_1964* has a sample period of 1964 – 2010. Panel B shows summary statistics for the control variables. The start year of the sample period for a variable is indicated in the second column. All sample periods end in 2010. Definitions of all variables are in the Appendix. N denotes the number of firm-year observations.

Name	Start year	Unit	Mean	Median	Std. Dev.	Std. Err.	Min.	Max.	N
Panel A: Main Variables									
CashRatio_1964	1964		0.14	0.07	0.18	0.0006	0.00	0.99	92,169
CashRatio_1971	1971		0.15	0.07	0.19	0.0006	0.00	0.99	86,002
CashRatio_1980	1980		0.16	0.08	0.20	0.0007	0.00	0.99	73,159
CashRatio_1994	1994		0.18	0.09	0.21	0.0010	0.00	0.99	41,590
ILLIQ_1964	1964	1/Million$	7.84	1.27	11.22	0.0370	0.25	30	92,169
ILLIQ_1971	1971	1/Million$	8.33	1.50	11.45	0.0390	0.25	30	86,002
ILLIQ_1980	1980	1/Million$	9.04	1.74	11.84	0.0438	0.25	30	73,159
ILLIQ_1994	1994	1/Million$	8.80	1.37	11.91	0.0584	0.25	30	41,590
Log_resprd	1994		-5.18	-5.02	1.29	0.0063	-9.17	-1.61	41,573
Panel B: Control Variables									
Price-nonsynchronicity	1964		1.66	1.63	1.81	0.0061	-12.07	16.35	88,136
Firm Size	1964	log(Million$)	3.49	3.39	1.94	0.0064	-2.14	10.73	92,169
Market Capitalization - log	1964	log(Million$)	3.26	3.10	1.95	0.0064	-2.17	11.32	92,169
Leverage	1964		0.23	0.21	0.19	0.0006	0.00	1.00	92,169
MTB	1964		1.69	1.29	1.26	0.0042	0.17	29.70	92,169
Firm Age	1964	log(month)	4.66	4.84	1.03	0.0034	1.61	6.60	92,169
Net Working Capital	1964		0.15	0.14	0.19	0.0006	-0.67	0.92	92,169
Net Equity Issuance	1971		0.04	0.00	0.16	0.0005	-2.11	2.95	86,002
Net Debt Issuance	1971		0.01	0.00	0.11	0.0004	-5.27	1.22	86,002
Dividend Dummy	1964		0.42	0	0.49	0.0016	0	1	92,169
R&D	1964		0.03	0	0.07	0.0002	0.00	0.85	92,169

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Table 1 – continued from previous page

Name	Start year	Unit	Mean	Median	Std. Dev.	Std. Err.	Min.	Max.	N
Capital Expenditure	1964		0.07	0.05	0.06	0.0002	0.00	0.51	92,169
Acquisition	1971		0.02	0.00	0.05	0.0002	0.00	0.44	86,002
Cash Flow	1964		0.04	0.07	0.15	0.0005	-1.51	1.63	92,169
Industry Sigma	1964		0.07	0.06	0.04	0.0001	0.01	0.19	92,169
Stock Price - log	1964	log($)	1.00	1.09	1.32	0.0044	-4.52	6.16	92,169
Stock Return, Annualized	1964		0.12	0.04	0.61	0.0021	-1.00	8.73	87,333
Stock Return Volatility	1964		0.04	0.03	0.02	0.0001	0.00	1.22	92,169
Equity Beta	1964		0.88	0.84	0.62	0.0021	-2.00	3.49	90,918
Analyst Coverage	1976		1.09	0.98	1.02	0.0036	0.00	3.89	78,857
Inst. Own ($< 5\%$)	1980		0.11	0.07	0.12	0.0005	0.00	0.91	70,449
Inst. Own ($> 5\%$)	1980		0.23	0.17	0.21	0.0008	0.00	0.99	70,449
Inst. Turnover	1980		0.09	0.09	0.04	0.0002	0.00	0.58	70,707
IPO1	1964		0.06	0	0.24	0.0008	0	1	92,169
IPO2	1964		0.06	0	0.24	0.0008	0	1	92,169
IPO3	1964		0.06	0	0.23	0.0008	0	1	92,169
IPO4	1964		0.05	0	0.22	0.0007	0	1	92,169
IPO5	1964		0.05	0	0.22	0.0007	0	1	92,169

Table 2
Correlations

Pairwise correlations of the variables listed in Table 1. The reported correlations are taken over the longest overlapping sample periods of each pair of variables. The sample period is from 1964 to 2010 for all variables, except Net Equity Issuance, Net Debt Issuance, and Acquisition (1971-2010); Analyst Coverage (1976-2010); Inst. Own (< 5%), Inst. Own (> 5%), and Inst. Turnover (1980-2010); and Log_resprd (1993-2010).

	Cash Ratio	*ILLIQ*	Log_ resprd	*Prc-Nschr*	Firm Size	Lever -age	MTB	Firm Age	Net WCap	Net Equity	Net Debt	Div. Dum.	R&D	CapX	Acq	Cash Flow	Ind. Sigma	Equity Beta	Ana. Cov.	InstO (> 5%)	InstO (< 5%)	Inst. T.O.
Cash Ratio	1																					
ILLIQ	0.02	1																				
Log_resprd	0.02	0.75	1																			
Price-nonsynchronicity	0.08	0.45	0.59	1																		
Firm Size	-0.25	-0.64	-0.81	-0.57	1																	
Leverage	-0.42	0.05	0.01	-0.01	0.17	1																
MTB	0.37	-0.12	-0.15	-0.02	-0.14	-0.22	1															
Firm Age	-0.21	-0.16	-0.29	-0.22	0.39	0.01	-0.20	1														
Net Working Capital	-0.26	-0.05	0.11	0.02	-0.07	-0.16	-0.16	0.08	1													
Net Equity Issuance	0.34	0.04	0.17	0.10	-0.24	-0.12	0.32	-0.36	-0.11	1												
Net Debt Issuance	-0.02	-0.07	-0.04	-0.04	0.06	0.17	0.00	-0.01	0.02	-0.11	1											
Dividend Dummy	-0.22	-0.37	-0.36	-0.31	0.46	-0.05	-0.13	0.36	0.17	-0.19	0.04	1										
R&D	0.48	0.07	0.09	0.12	-0.22	-0.24	0.31	-0.12	-0.12	0.24	-0.01	-0.24	1									
Capital Expenditure	-0.15	-0.10	-0.02	-0.08	0.07	0.09	0.04	-0.10	-0.21	0.04	0.17	0.06	-0.11	1								
Acquisition	-0.08	-0.08	-0.11	-0.04	0.10	0.09	0.01	-0.04	-0.06	0.02	0.23	-0.02	-0.04	-0.08	1							
Cash Flow	-0.30	-0.25	-0.29	-0.19	0.33	-0.02	-0.14	0.17	0.22	-0.40	-0.03	0.21	-0.44	0.13	0.06	1						
Industry Sigma	0.38	0.17	-0.02	0.16	-0.21	-0.18	0.27	-0.08	-0.23	0.14	-0.02	-0.36	0.42	-0.14	0.08	-0.20	1					
Equity Beta	0.06	-0.39	-0.41	-0.38	0.26	0.01	0.10	0.00	0.00	0.05	0.04	0.03	0.06	0.06	0.01	0.06	-0.07	1				
Analyst Coverage	-0.01	-0.55	-0.70	-0.47	0.68	-0.06	0.12	0.20	-0.09	-0.12	0.05	0.26	0.02	0.10	0.09	0.23	0.05	0.29	1			
Inst. Own (> 5%)	0.00	-0.21	-0.29	-0.12	0.27	0.01	-0.08	0.10	-0.03	-0.12	-0.01	0.02	-0.02	-0.07	0.06	0.11	0.05	0.07	0.19	1		
Inst. Own (< 5%)	-0.03	-0.58	-0.85	-0.51	0.73	-0.06	0.09	0.29	-0.09	-0.16	0.04	0.28	-0.06	0.00	0.13	0.27	0.06	0.32	0.70	0.33	1	
Inst. Turnover	0.16	-0.18	-0.09	-0.06	0.03	-0.06	0.15	-0.25	-0.08	0.18	0.03	-0.15	0.08	0.05	0.07	-0.01	0.09	0.18	0.11	0.08	0.15	1

Table 3

Fama-MacBeth regressions of Cash Ratio on *ILLIQ_res* and controls

This table presents Fama-MacBeth (1973) estimators for regressions of the type:

$$\text{Cash Ratio}_{i,t} = \beta_0 + \beta_1 ILLIQ\_res_{i,t-1} + \mathbf{\Gamma}'\mathbf{Z}_{i,t} + \varepsilon_{i,t},$$

where $\mathbf{Z}$ is a vector of control variables and $\mathbf{\Gamma}$ the corresponding vector of regression coefficients. Regressions are run over the following three time periods: 1964-2010 (the full sample period), 1971-2010 (Net Equity Issuance, Net Debt Issuance, and Acquisition are available from 1971), and 1980-2010 (analyst coverage and institutional holding data are available from 1976 and 1980, respectively). Two sets of regressions are run for each time period: one with and one without lagged Price-nonsynch_res as a control. t values are calculated based on Newey-West (1987) standard errors with 2 lags. Statistical significance at the 1%, 5% and 10% level are indicated by ***a***, ***b***, and ***c*** respectively.

Cash Ratio	Since 1964		Since 1971		Since 1980	
Intercept	0.2304^{a}	0.2290^{a}	0.2636^{a}	0.2641^{a}	0.2672^{a}	0.2685^{a}
	(14.37)	(13.77)	(20.92)	(20.78)	(26.16)	(28.62)
Lag(*ILLIQ*_res)	-0.0025^{a}	-0.0024^{a}	-0.0016^{a}	-0.0016^{a}	-0.0015^{a}	-0.0015^{a}
	(-3.81)	(-3.95)	(-7.98)	(-8.07)	(-13.70)	(-12.92)
Lag(Price-nonsynch_res)		-0.0010^{a}		-0.0009^{a}		-0.0008^{b}
		(-3.33)		(-3.40)		(-2.13)
Firm Size	-0.0098^{a}	-0.0096^{a}	-0.0094^{a}	-0.0091^{a}	-0.0104^{a}	-0.0101^{a}
	(-12.52)	(-11.79)	(-10.65)	(-10.06)	(-10.86)	(-10.46)
Leverage	-0.2633^{a}	-0.2612^{a}	-0.2897^{a}	-0.2878^{a}	-0.3110^{a}	-0.3108^{a}
	(-15.22)	(-14.68)	(-19.80)	(-18.69)	(-29.39)	(-28.66)
MTB	0.0211^{a}	0.0207^{a}	0.0192^{a}	0.0188^{a}	0.0160^{a}	0.0154^{a}
	(13.39)	(12.56)	(9.28)	(8.63)	(11.02)	(11.07)
Firm Age	-0.0013	-0.001	-0.0045^{b}	-0.0047^{b}	-0.0048^{b}	-0.0052^{b}
	(-0.42)	(-0.32)	(-2.18)	(-2.25)	(-2.19)	(-2.49)
Net Working Capital	-0.2386^{a}	-0.2370^{a}	-0.2585^{a}	-0.2582^{a}	-0.2762^{a}	-0.2778^{a}
	(-25.34)	(-23.88)	(-26.19)	(-25.03)	(-30.02)	(-30.87)
Net Equity Issuance			0.0891^{a}	0.0896^{a}	0.1109^{a}	0.1132^{a}
			(4.98)	(4.84)	(6.19)	(6.29)
Net Debt Issuance			0.1909^{a}	0.1901^{a}	0.2123^{a}	0.2141^{a}
			(10.98)	(10.64)	(10.65)	(10.80)
Dividend Dummy	-0.0095^{a}	-0.0099^{a}	-0.0099^{b}	-0.0104^{a}	-0.0131^{a}	-0.0134^{a}
	(-2.71)	(-2.78)	(-2.71)	(-2.88)	(-5.18)	(-4.96)
R&D	0.2491^{a}	0.2557^{a}	0.3057^{a}	0.3121^{a}	0.3777^{a}	0.3845^{a}
	(3.67)	(3.76)	(4.86)	(5.00)	(6.74)	(6.95)
Capital Expenditure	-0.4330^{a}	-0.4365^{a}	-0.5469^{a}	-0.5509^{a}	-0.5985^{a}	-0.6032^{a}
	(-14.24)	(-14.81)	(-16.19)	(-16.16)	(-16.35)	(-16.51)
Acquisition			-0.3713^{a}	-0.3711^{a}	-0.4198^{a}	-0.4202^{a}
			(-11.52)	(-11.30)	(-11.69)	(-11.45)
Cash Flow	-0.0644^{a}	-0.0607^{a}	-0.0079	-0.005	-0.0175	-0.0144
	(-5.45)	(-5.33)	(-0.82)	(-0.51)	(-1.54)	(-1.32)

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Table 3 – continued from previous page

Cash Ratio	Since 1964		Since 1971		Since 1980	
Lag(Industry Sigma)	0.3812^{a}	0.3349^{a}	0.3340^{a}	0.3085^{a}	0.3304^{a}	0.3268^{a}
	(5.25)	(4.76)	(7.70)	(6.32)	(8.56)	(7.52)
Lag(Equity Beta)	0.0109^{a}	0.0106^{a}	0.0115^{a}	0.0112^{a}	0.0129^{a}	0.0127^{a}
	(4.95)	(4.71)	(4.75)	(4.49)	(4.61)	(4.38)
Analyst Coverage_res					0.0035^{b}	0.0035^{c}
					(2.07)	(1.90)
Inst. Own. ($> 5\%$)					0.0401^{a}	0.0407^{a}
					(5.83)	(5.81)
Inst. Own. ($< 5\%$)_res					0.0197^{a}	0.0188^{b}
					(3.09)	(2.65)
Inst. Turnover					0.1140^{a}	0.1170^{a}
					(3.73)	(4.05)
IPO2	0.0119^{b}	0.0140^{b}	0.0104^{c}	0.0117^{c}	0.0191^{b}	0.0196^{b}
	(2.10)	(2.47)	(1.73)	(1.95)	(2.58)	(2.67)
IPO3	0.0011	0.0019	-0.0015	-0.0016	0.0012	0.0007
	(0.27)	(0.44)	(-0.38)	(-0.40)	(0.26)	(0.13)
IPO4	0.0023	0.0021	0.0003	0.0002	0.0013	0.0011
	(0.60)	(0.54)	(0.06)	(0.05)	(0.31)	(0.24)
IPO5	0.0015	0.0019	-0.0009	-0.0000	0.0017	0.0022
	(0.39)	(0.45)	(-0.19)	(-0.01)	(0.33)	(0.40)
R^2	0.40	0.40	0.43	0.43	0.47	0.47
N	78,500	75,157	73,597	70,604	59,921	57,611

Table 4

How different variables affect cash holdings: Our baseline results compared with the literature

This table compares the signs of the regression coefficients in the last column of Table 3 (Sign Us) to what has been found in standard references in the literature (Sign Lit.). '+' or '−' means that the coefficient of the variable is significant at the 5 or 1% levels. NS stands for not significant at conventional levels (10% or better). †The statistical significance of Price-nonsynchronicity is not robust to adding variables that interact stock liquidity with the growth opportunity measures, MTB or R&D (see Table 5 for details).

*These papers study cash savings rather than cash holdings.

Variable	Sign Us	Sign Lit.	Literature
Panel A: New variables in this paper			
Stock Liquidity	+		
Firm Age	−		
Equity Beta	+		
Panel B: Variables used in the cash holding literature			
Price-nonsynchronicity	$-/NS^{\dagger}$	+	Fresard (2012)*
Firm Size	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
MTB	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Leverage	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Industry Sigma	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009), Han and Qiu (2007)
R&D	+	+	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009), Brown and Petersen (2011)
Net Equity Issuance	+	+	Bates, Kahle, and Stulz (2009), McLean (2011)
Net Debt Issuance	+	+	Bates, Kahle, and Stulz (2009)
Net Working Capital	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Capital Expenditure	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Acquisition	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Dividend Dummy	−	−	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009)
Cash Flow	NS	mixed	Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009),Riddick and Whited (2009)*
Analyst Coverage	+	+	Chang (2012)
Institutional ownership	+	+	Brown, Chen and Shekhar (2011)
Institutional Turnover	+	+	Brown, Chen and Shekhar (2011)
IPO2	+	+	Bates, Kahle, and Stulz (2009)
IPO3	NS	+	Bates, Kahle, and Stulz (2009)
IPO4	NS	+	Bates, Kahle, and Stulz (2009)
IPO5	NS	+	Bates, Kahle, and Stulz (2009)

Table 5
Cash ratio sensitivity to growth opportunities

This table presents Fama-MacBeth (1973) and industry and year fixed effect estimators for the specification

$$\text{Cash Ratio}_{i,t} = \alpha_0 + \alpha_1 Liq\_res_{i,t-1} + \alpha_2 \cdot G_t \times Liq\_res_{i,t-1} + \mathbf{\Gamma}_1' \mathbf{X}_{i,t} + \varepsilon_{i,t}$$

in columns (1), (2), (5), and (6), and the specification

$$\text{Cash Ratio}_{i,t} = \beta_0 + \beta_1 Liq\_res_{i,t-1} + \beta_2 \cdot G_t \times Liq\_res_{i,t-1} + \beta_3 \cdot G_t \times \text{Firm Size}_{i,t-1} + \beta_4 \cdot G_t \times \text{Price-nonsynch\_res}_{i,t-1} + \mathbf{\Gamma}_2' \mathbf{Z}_{i,t} + \eta_{i,t}$$

in columns (3), (4), (7), and (8), where *Liq_res* is *Log_resprd_res* or *ILLIQ_res*, G is MTB in Panel A and $R\&D$ in Panel B, X and Z are vectors of control variables and $\mathbf{\Gamma}_1$ and $\mathbf{\Gamma}_2$ are the corresponding vectors of regression coefficients. The sample period is from 1994 to 2010. t values for the Fama-MacBeth estimators are calculated based on Newey-West (1987) standard errors with 2 lags. t values for the industry and year fixed effect estimators are adjusted for heteroskedasticity by firm cluster. Statistical significance at the 1%, 5% and 10% level are indicated by ***a***, ***b***, and ***c*** respectively.

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: MTB								
Intercept	0.2617^{a}	0.2577^{a}	0.2769^{a}	0.2808^{a}	0.3055^{a}	0.2995^{a}	0.3135^{a}	0.3125^{a}
	(33.21)	(31.75)	(38.11)	(31.15)	(21.25)	(20.87)	(21.38)	(21.28)
Lag(Log_resprd_res)	-0.0127^{b}		-0.0110^{b}		-0.0121^{a}		-0.0111^{a}	
	(-2.86)		(-2.36)		(-3.10)		(-2.83)	
Lag(*ILLIQ*_res)		-0.0007^{a}		-0.0005^{a}		-0.0007^{a}		-0.0005^{b}
		(-4.96)		(-3.15)		(-2.58)		(-2.01)
MTB × Lag(Log_resprd_res)	-0.0051^{a}		-0.0054^{a}		-0.0048^{a}		-0.0049^{a}	
	(-3.28)		(-4.08)		(-2.61)		(-2.67)	
MTB × Lag(*ILLIQ*_res)		-0.0004^{a}		-0.0006^{a}		-0.0003^{b}		-0.0004^{a}
		(-6.01)		(-6.42)		(-2.46)		(-3.33)
MTB × Lag(Price-nonsynch_res)			0.0013^{b}	0.0011			0.0008	0.0007
			(2.34)	(1.74)			(1.37)	(1.19)
MTB × Lag(Firm Size)			0.0030^{a}	0.0043^{a}			0.0017^{a}	0.0027^{a}
			(4.61)	(6.52)			(2.80)	(4.23)
Lag(Price-nonsynch_res)	0.0004	-0.0002	-0.0018	-0.0021^{c}	-0.0003	-0.001	-0.0015	-0.0019^{c}
	(-0.94)	(-0.52)	(-1.72)	(-1.91)	(-0.52)	(-1.51)	(-1.44)	(-1.79)
Lag(Firm Size)			-0.0161^{a}	-0.0180^{a}			-0.0147^{a}	-0.0162^{a}
			(-11.00)	(-12.22)			(-10.32)	(-11.27)

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Table 5 – continued from previous page

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Size	-0.0097^{a}	-0.0092^{a}			-0.0105^{a}	-0.0102^{a}		
	(-12.33)	(-12.01)			(-10.34)	(-9.95)		
Leverage	-0.3053^{a}	-0.3109^{a}	-0.3023^{a}	-0.3061^{a}	-0.3101^{a}	-0.3155^{a}	-0.3077^{a}	-0.3116^{a}
	(-44.38)	(-42.16)	(-44.71)	(-44.02)	(-30.53)	(-30.91)	(-30.37)	(-30.70)
MTB	0.0127^{a}	0.0146^{a}	0.0045^{b}	0.0014	0.0088^{a}	0.0103^{a}	0.0042^{b}	0.0025
	(5.09)	(7.35)	(2.55)	(1.25)	(6.27)	(7.32)	(1.99)	(1.09)
Firm Age	-0.0077^{a}	-0.0065^{a}	-0.0072^{a}	-0.0060^{a}	-0.0111^{a}	-0.0096^{a}	-0.0106^{a}	-0.0090^{a}
	(-3.87)	(-3.66)	(-3.82)	(-3.53)	(-5.11)	(-4.41)	(-4.90)	(-4.15)
Net Working Capital	-0.2881^{a}	-0.2894^{a}	-0.2880^{a}	-0.2893^{a}	-0.3130^{a}	-0.3149^{a}	-0.3122^{a}	-0.3139^{a}
	(-24.71)	(-23.23)	(-24.96)	(-23.08)	(-27.81)	(-27.73)	(-27.95)	(-27.90)
Net Equity Issuance	0.1295^{a}	0.1186^{a}	0.1288^{a}	0.1226^{a}	0.1220^{a}	0.1119^{a}	0.1176^{a}	0.1108^{a}
	(8.54)	(7.54)	(8.77)	(8.06)	(10.29)	(9.27)	(9.93)	(9.23)
Net Debt Issuance	0.2388^{a}	0.2449^{a}	0.2280^{a}	0.2337^{a}	0.2054^{a}	0.2126^{a}	0.1944^{a}	0.2011^{a}
	(8.48)	(9.01)	(8.28)	(8.71)	(8.71)	(8.92)	(8.46)	(8.67)
Dividend Dummy	-0.0173^{a}	-0.0164^{a}	-0.0155^{a}	-0.0145^{a}	-0.0120^{a}	-0.0105^{a}	-0.0104^{a}	-0.0088^{b}
	(-4.42)	(-4.31)	(-3.92)	(-3.85)	(-3.25)	(-2.84)	(-2.82)	(-2.39)
R&D	0.5173^{a}	0.5221^{a}	0.5171^{a}	0.5207^{a}	0.4266^{a}	0.4184^{a}	0.4304^{a}	0.4213^{a}
	(14.32)	(12.65)	(14.35)	(12.64)	(14.68)	(14.31)	(14.88)	(14.50)
Capital Expenditure	-0.6748^{a}	-0.6779^{a}	-0.6731^{a}	-0.6748^{a}	-0.6165^{a}	-0.6164^{a}	-0.6181^{a}	-0.6181^{a}
	(-14.83)	(-15.44)	(-14.93)	(-15.39)	(-23.84)	(-23.70)	(-24.08)	(-23.98)
Acquisition	-0.5012^{a}	-0.5001^{a}	-0.5106^{a}	-0.5096^{a}	-0.4458^{a}	-0.4436^{a}	-0.4572^{a}	-0.4551^{a}
	(-11.96)	(-12.29)	(-12.30)	(-12.58)	(-22.60)	(-22.18)	(-23.39)	(-23.02)
Cash Flow	-0.0126	-0.0111	-0.0254^{c}	-0.0254^{b}	-0.0087	-0.0079	-0.0207^{c}	-0.0216^{c}
	(-1.10)	(-0.95)	(-2.09)	(-2.14)	(-0.73)	(-0.66)	(-1.77)	(-1.84)
Lag(Industry Sigma)	0.4246^{a}	0.4314^{a}	0.4040^{a}	0.4070^{a}	0.1418^{b}	0.1537^{b}	0.1381^{b}	0.1475^{b}
	(10.28)	(9.79)	(10.13)	(9.76)	(2.07)	(2.23)	(2.02)	(2.15)

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Table 5 – continued from previous page

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag(Equity Beta)	0.0196^{a}	0.0176^{a}	0.0210^{a}	0.0189^{a}	0.0168^{a}	0.0154^{a}	0.0176^{a}	0.0160^{a}
	(6.00)	(4.58)	(6.19)	(4.70)	(9.15)	(8.24)	(9.60)	(8.62)
Analyst Coverage_res	0.0060^{a}	0.0081^{a}	0.0049^{a}	0.0065^{a}	0.0077^{a}	0.0092^{a}	0.0070^{a}	0.0081^{a}
	(5.69)	(4.87)	(5.59)	(4.41)	(4.03)	(4.91)	(3.70)	(4.33)
Inst. Own ($> 5\%$)	0.0585^{a}	0.0538^{a}	0.0672^{a}	0.0629^{a}	0.0621^{a}	0.0593^{a}	0.0687^{a}	0.0663^{a}
	(8.32)	(7.32)	(9.57)	(8.56)	(5.92)	(5.52)	(6.52)	(6.16)
Inst. Own ($< 5\%$)_res	0.0131	0.0281^{a}	0.0145	0.0266^{b}	0.0280^{b}	0.0438^{a}	0.0294^{a}	0.0429^{a}
	(1.64)	(2.98)	(1.62)	(2.53)	(2.53)	(4.03)	(2.66)	(3.97)
Inst. Turnover	0.1916^{a}	0.1610^{a}	0.1870^{a}	0.1613^{a}	0.2023^{a}	0.1728^{a}	0.1962^{a}	0.1693^{a}
	(5.55)	(3.85)	(5.52)	(4.04)	(5.17)	(4.40)	(5.01)	(4.31)
IPO2	0.0207^{b}	0.0187^{b}	0.0219^{a}	0.0201^{a}	0.0148^{a}	0.0145^{a}	0.0157^{a}	0.0154^{a}
	(2.78)	(2.79)	(2.93)	(2.94)	(3.18)	(3.12)	(3.37)	(3.31)
IPO3	0.0028	0.003	0.0037	0.0041	0.0007	0.0014	0.0015	0.0025
	(0.43)	(0.48)	(0.55)	(0.66)	(0.16)	(0.33)	(0.36)	(0.60)
IPO4	-0.0020	-0.0004	-0.0010	0.0008	-0.0023	-0.0013	-0.0017	-0.0005
	(-0.40)	(-0.09)	(-0.19)	(-0.17)	(-0.59)	(-0.34)	(-0.44)	(-0.12)
IPO5	-0.0042	-0.0043	-0.0035	-0.0038	-0.0047	-0.0047	-0.0043	-0.0043
	(-1.24)	(-1.54)	(-1.05)	(-1.40)	(-1.26)	(-1.25)	(-1.17)	(-1.14)
R^2	0.54	0.54	0.54	0.54				
Adj-R^2					0.54	0.54	0.55	0.55
N	34,594	33,990	34,594	33,990	34,594	33,990	34,594	33,990

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Table 5 – continued from previous page

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B: R&D								
Intercept	0.2614^{a}	0.2578^{a}	0.2798^{a}	0.2764^{a}	0.3043^{a}	0.2991^{a}	0.3148^{a}	0.3104^{a}
	(33.49)	(31.44)	(36.21)	(30.23)	(21.21)	(20.83)	(21.92)	(21.62)
Lag(Log_resprd_res)	-0.0160^{a}		-0.0153^{a}		-0.0157^{a}		-0.0154^{a}	
	(-4.66)		(-4.45)		(-6.22)		(-6.15)	
Lag(*ILLIQ*_res)		-0.0009^{a}		-0.0010^{a}		-0.0009^{a}		-0.0010^{a}
		(-9.11)		(-10.40)		(-4.83)		(-5.44)
R&D × Lag(Log_resprd_res)	-0.1191^{a}		-0.1019^{a}		-0.1171^{a}		-0.0904^{a}	
	(-3.73)		(-3.24)		(-3.66)		(-2.85)	
R&D × Lag(*ILLIQ*_res)		-0.0089^{a}		-0.0054^{a}		-0.0060^{a}		-0.0033
		(-4.45)		(-3.55)		(-2.89)		(-1.60)
R&D × Lag(Price-nonsynch_res)			-0.0113^{c}	-0.0179^{a}			-0.0177	-0.0237^{b}
			(-2.10)	(-2.96)			(-1.63)	(-2.26)
R&D × Lag(Firm Size)			0.1173^{a}	0.1151^{a}			0.1180^{a}	0.1180^{a}
			(6.68)	(6.47)			(7.98)	(7.84)
Lag(Price-nonsynch_res)	0.0004	-0.0001	0.0002	-0.0001	-0.0003	-0.0009	-0.0000	-0.0003
	(-0.84)	(-0.35)	(-0.41)	(-0.18)	(-0.53)	(-1.42)	(-0.01)	(-0.49)
Lag(Firm Size)			-0.0144^{a}	-0.0142^{a}			-0.0154^{a}	-0.0153^{a}
			(-13.77)	(-13.79)			(-14.83)	(-14.69)
Firm Size	-0.0099^{a}	-0.0097^{a}			-0.0106^{a}	-0.0105^{a}		
	(-12.75)	(-11.97)			(-10.48)	(-10.34)		
Leverage	-0.3071^{a}	-0.3118^{a}	-0.3016^{a}	-0.3055^{a}	-0.3111^{a}	-0.3158^{a}	-0.3055^{a}	-0.3095^{a}
	(-45.08)	(-42.14)	(-43.78)	(-42.31)	(-30.76)	(-30.99)	(-30.64)	(-30.82)
MTB	0.0147^{a}	0.0162^{a}	0.0148^{a}	0.0161^{a}	0.0106^{a}	0.0116^{a}	0.0108^{a}	0.0116^{a}
	(7.92)	(8.59)	(7.74)	(8.39)	(8.15)	(8.74)	(8.25)	(8.78)

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Table 5 – continued from previous page

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Age	-0.0077^{a}	-0.0066^{a}	-0.0077^{a}	-0.0066^{a}	-0.0110^{a}	-0.0097^{a}	-0.0102^{a}	-0.0089^{a}
	(-3.86)	(-3.58)	(-4.36)	(-4.05)	(-5.07)	(-4.44)	(-4.72)	(-4.09)
Net Working Capital	-0.2878^{a}	-0.2875^{a}	-0.2880^{a}	-0.2883^{a}	-0.3125^{a}	-0.3134^{a}	-0.3054^{a}	-0.3068^{a}
	(-24.39)	(-22.84)	(-23.54)	(-22.25)	(-27.82)	(-27.57)	(-27.49)	(-27.28)
Net Equity Issuance	0.1261^{a}	0.1182^{a}	0.1336^{a}	0.1267^{a}	0.1196^{a}	0.1123^{a}	0.1241^{a}	0.1170^{a}
	(7.67)	(7.49)	(9.92)	(10.10)	(10.09)	(9.32)	(10.54)	(9.79)
Net Debt Issuance	0.2380^{a}	0.2442^{a}	0.2288^{a}	0.2346^{a}	0.2062^{a}	0.2133^{a}	0.1960^{a}	0.2024^{a}
	(8.48)	(9.11)	(8.34)	(8.84)	(8.81)	(8.94)	(8.64)	(8.75)
Dividend Dummy	-0.0171^{a}	-0.0165^{a}	-0.0124^{a}	-0.0117^{a}	-0.0117^{a}	-0.0105^{a}	-0.0069^{c}	-0.0056
	(-4.35)	(-4.37)	(-3.26)	(-3.31)	(-3.20)	(-2.84)	(-1.87)	(-1.52)
R&D	0.4935^{a}	0.4990^{a}	0.2117^{a}	0.2237^{a}	0.4015^{a}	0.3957^{a}	0.1472^{a}	0.1446^{a}
	(13.84)	(12.49)	(6.13)	(7.17)	(13.59)	(13.27)	(3.35)	(3.28)
Capital Expenditure	-0.6756^{a}	-0.6769^{a}	-0.6646^{a}	-0.6654^{a}	-0.6172^{a}	-0.6169^{a}	-0.6217^{a}	-0.6215^{a}
	(-15.23)	(-15.54)	(-15.37)	(-15.72)	(-23.85)	(-23.70)	(-24.26)	(-24.13)
Acquisition	-0.5014^{a}	-0.4990^{a}	-0.5163^{a}	-0.5147^{a}	-0.4467^{a}	-0.4441^{a}	-0.4620^{a}	-0.4598^{a}
	(-12.14)	(-12.59)	(-12.18)	(-12.64)	(-22.67)	(-22.21)	(-23.77)	(-23.34)
Cash Flow	-0.0103	-0.0087	-0.0329^{b}	-0.0312^{b}	-0.0069	-0.0066	-0.0278^{b}	-0.0276^{b}
	(-0.91)	(-0.80)	(-2.38)	(-2.38)	(-0.58)	(-0.55)	(-2.37)	(-2.34)
Lag(Industry Sigma)	0.4239^{a}	0.4313^{a}	0.3594^{a}	0.3658^{a}	0.1445^{b}	0.1558^{b}	0.1025	0.1101
	(10.58)	(9.91)	(8.45)	(8.14)	(2.11)	(2.26)	(1.51)	(1.61)
Lag(Equity Beta)	0.0192^{a}	0.0177^{a}	0.0178^{a}	0.0163^{a}	0.0164^{a}	0.0153^{a}	0.0158^{a}	0.0146^{a}
	(5.99)	(4.67)	(6.03)	(4.55)	(8.94)	(8.19)	(8.76)	(7.98)
Analyst Coverage_res	0.0058^{a}	0.0078^{a}	0.0041^{a}	0.0059^{a}	0.0074^{a}	0.0089^{a}	0.0056^{a}	0.0070^{a}
	(5.54)	(4.47)	(5.13)	(4.24)	(3.90)	(4.74)	(2.97)	(3.75)
Inst. Own ($> 5\%$)	0.0590^{a}	0.0562^{a}	0.0623^{a}	0.0592^{a}	0.0624^{a}	0.0609^{a}	0.0643^{a}	0.0622^{a}
	(8.18)	(7.67)	(8.91)	(8.24)	(5.97)	(5.67)	(6.17)	(5.81)

Continued on next page

Table 5 – continued from previous page

	Fama-MacBeth				Fixed Effect (Industry and Year)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inst. Own ($< 5\%$)_res	0.0156^{c}	0.0322^{a}	0.0208^{b}	0.0354^{a}	0.0298^{a}	0.0461^{a}	0.0360^{a}	0.0504^{a}
	(1.93)	(3.26)	(2.35)	(3.31)	(2.69)	(4.25)	(3.26)	(4.65)
Inst. Turnover	0.1846^{a}	0.1591^{a}	0.1770^{a}	0.1544^{a}	0.1981^{a}	0.1729^{a}	0.1846^{a}	0.1610^{a}
	(5.34)	(3.59)	(5.34)	(3.65)	(5.05)	(4.39)	(4.73)	(4.11)
IPO2	0.0212^{b}	0.0195^{b}	0.0217^{a}	0.0202^{a}	0.0154^{a}	0.0149^{a}	0.0170^{a}	0.0165^{a}
	(2.83)	(2.86)	(2.99)	(2.98)	(3.31)	(3.19)	(3.66)	(3.55)
IPO3	0.0026	0.0031	0.0025	0.0028	0.001	0.0013	0.0021	0.0025
	(0.39)	(0.50)	(0.38)	(0.46)	(0.23)	(0.31)	(0.50)	(0.59)
IPO4	-0.0018	-0.0007	-0.0013	-0.0001	-0.0017	-0.0015	-0.0009	-0.0004
	(-0.34)	(-0.14)	(-0.27)	(-0.03)	(-0.44)	(-0.37)	(-0.23)	(-0.10)
IPO5	-0.0039	-0.0043	-0.0034	-0.0038	-0.0044	-0.0048	-0.0034	-0.0037
	(-1.12)	(-1.52)	(-1.11)	(-1.57)	(-1.19)	(-1.27)	(-0.92)	(-0.99)
R^2	0.54	0.54	0.55	0.55				
Adj-R^2					0.55	0.54	0.55	0.55
N	34,594	33,990	34,594	33,990	34,594	33,990	34,594	33,990

Table 6
Endogeneity: Decimalization test with placebo robustness analysis

Panel A shows the OLS estimators of the specification

$$\Delta\text{Cash Ratio}_i = \beta_0 + \beta_1 \text{Dummy\_Active}_i + \mathbf{\Gamma}'(\Delta\mathbf{Z}_i) + \varepsilon_i,$$

where ΔCash Ratio$_i$ is the change in the Cash Ratio for firm i from the fiscal year prior to decimalization (2000) to the year after (2002), *Dummy_Active* is an indicator variable that equals 1 for the 50% most active stocks and 0 for the least active stocks, $\Delta\mathbf{Z}_i$ is a vector of changes in the control variables for firm i from the year prior to decimalization to the year after, and $\mathbf{\Gamma}$ is the corresponding vector of regression coefficients. The control variables include all those in Table 3 and IPO1, which is a dummy for the first year after an IPO. Panel B displays the results of placebo tests, in which the regression is re-run for each year from 1996 to 2006 (i.e. where 1996, for example, takes the place of 2001 in the original test). In Panel B, only $\hat{\beta}_1$ is shown. t-values are calculated using White's (1980) adjustment for heteroscedasticity. Statistical significance at the 1%, 5% and 10% level are indicated by ***a***, ***b***, and ***c*** respectively.

	Coefficient	t-value
Panel A: Decimalization test		
Intercept	0.0045	0.82
Dummy_Active	**0.0182**^{a}	**3.09**
Δ Price-nonsynch_res	0.0002	0.13
Δ Firm Size	-0.0160	-1.54
Δ Leverage	-0.2548^{a}	-7.10
Δ MTB	0.0018	0.58
Δ Net Working Capital	-0.2198^{a}	-6.30
Δ Net Equity Issuance	0.1492^{a}	5.35
Δ Net Debt Issuance	0.1187^{a}	2.63
Δ Dividend Dummy	-0.0030	-0.33
Δ R&D	-0.2210^{c}	-1.77
Δ Capital Expenditure	-0.1864^{b}	-2.50
Δ Acquisition	-0.2334^{a}	-4.88
Δ Cash Flow	0.0006	0.02
Δ Industry Sigma	-0.1698	-0.68
Δ Equity Beta	-0.0081	-1.19
Δ Analyst Coverage_res	-0.0035	-0.58
Δ Inst. Own. ($< 5\%$)_res	0.0368	1.07
Δ Inst. Own. ($> 5\%$)	0.0737^{b}	2.21
Δ Inst. Turnover	-0.0751	-0.72
Δ IPO1	0.0075	0.33
Δ IPO2	-0.0126	-0.77
Δ IPO3	0.0252	1.49
Δ IPO4	-0.0047	-0.38
Δ IPO5	0.0060	0.49
#Obs	1387	
Adj-R^2	0.18	

Continued on next page

Table 6 – continued from previous page

	$\hat{\beta}_1$	t-value
Panel B: Placebo test		
Placebo year		
1996	0.0034	0.72
1997	0.0078	1.51
1998	0.0027	0.49
1999	0.0017	0.29
2000	-0.0004	-0.06
2001	**0.0182**^{a}	**3.09**
2002	0.0073	1.35
2003	-0.0041	-0.68
2004	-0.0009	-0.14
2005	0.0082	1.44
2006	-0.0028	-0.48

Table 7

Two-way causality: Simultaneous equation system

This table displays the results from running a system of two simultaneous equations:

$$\text{(i)} \quad \text{Cash Ratio}_{i,t} = \alpha_0 + \alpha_1 Liq\_res_{i,t} + \sum_{k=2}^{K} \alpha_k Z_{k,i,t-1} + \varepsilon_{i,t},$$

$$\text{(ii)} \quad Liq\_res_{i,t} = \beta_0 + \beta_1 \text{Cash Ratio}_{i,t} + \sum_{l=2}^{L} \beta_l X_{l,i,t-1} + \eta_{i,t},$$

where *Liq_res* is *ILLIQ_res* or *Log_resprd_res*, $Z_{k,i,t-1}$ are lagged controls in the Cash Ratio equation (i), and $X_{l,i,t-1}$ are lagged controls in the stock liquidity regression (ii). The system is estimated by a Fama-MacBeth procedure, using two-stage least squares (2SLS) for each yearly cross-section. In particular, for each year t, *Liq_res* (Cash Ratio) is regressed on all controls from both equations, yielding fitted values $\widehat{Liq\_res}$ ($\widehat{\text{Cash Ratio}}$), which are then used in the Cash Ratio (*Liq_res*) regression in place of *Liq_res* (Cash Ratio). The estimated coefficients are then averaged over all years. t values are calculated using Newey and West (1987) standard errors with two lags. Panel A shows the results of the Cash Ratio equation. Panel B shows the results of the stock liquidity equation. The sample period is from 1994 to 2010. Fama-French 48 industry dummies are included among the control variables in both equations, but their coefficients are not shown here. Statistical significance at the 1%, 5% and 10% level are indicated by ***a***, ***b***, and ***c*** respectively.

Liq_res is:	*Log_resprd_res*		*ILLIQ_res*	
	Coef.	t-value	Coef.	t-value
Panel A: Cash Ratio as dependent variable				
Intercept	0.2837^{a}	29.15	0.2917^{a}	19.29
Log_resprd_res	-0.0704^{a}	-9.93		
*ILLIQ*_res			-0.0065^{a}	-5.23
Price-nonsynch_res	0.0007^{c}	1.97	-0.0016^{a}	-4.60
Firm Size	-0.0160^{a}	-10.13	-0.0119^{a}	-13.30
Leverage	-0.2510^{a}	-31.53	-0.2583^{a}	-31.14
MTB	0.0029^{b}	2.48	0.0056^{a}	5.91
Firm Age	-0.0081^{a}	-3.58	-0.0051^{b}	-2.52
Net Working Capital	-0.2669^{a}	-24.00	-0.2784^{a}	-18.70
Net Equity Issuance	0.0475^{a}	3.34	0.0304^{c}	1.92
Net Debt Issuance	0.1705^{a}	12.50	0.1699^{a}	11.02
Dividend Dummy	-0.0214^{a}	-9.13	-0.0186^{a}	-6.80
R&D	0.4927^{a}	28.39	0.4823^{a}	23.37
Capital Expenditure	-0.5815^{a}	-14.73	-0.5857^{a}	-14.67
Acquisition	-0.4246^{a}	-22.42	-0.4342^{a}	-22.23
Cash Flow	-0.0596^{a}	-4.84	-0.0574^{a}	-3.67
Industry Sigma	0.1696	1.42	0.1720	1.48
Equity Beta	0.0136^{a}	4.01	-0.0007	-0.12
Analyst Coverage_res	0.0042^{b}	2.40	0.0076^{a}	4.06
Inst. Own ($> 5\%$)	0.0460^{a}	10.43	0.0076	0.62
Inst. Own ($< 5\%$)_res	-0.0871^{a}	-8.20	-0.0546^{a}	-4.17
Inst. Turnover	0.1337^{a}	5.32	0.0261	0.45
IPO2	0.0001	0.03	0.0032	0.78
IPO3	-0.0066^{c}	-1.87	-0.0058	-1.58
IPO4	-0.0070	-1.36	-0.0069	-1.49
IPO5	-0.0097^{b}	-2.35	-0.0096^{b}	-2.64

Continued on next page

Table 7 – continued from previous page

Liq_res is:	*Log_resprd_res*		*ILLIQ_res*	
	Coef.	*t*-value	Coef.	*t*-value
Panel B: Liq_res *as dependent variable*				
Intercept	0.3357^{a}	7.64	1.6659	1.54
Cash Ratio	-0.8219^{a}	-11.24	-7.4969^{a}	-5.21
Market Capitalization - log	-0.0245	-1.38	0.3384^{a}	3.09
Leverage	0.1986^{a}	5.33	2.1723^{a}	3.32
MTB	-0.0762^{a}	-10.54	-0.8518^{a}	-6.01
Firm Age	-0.0184	-1.13	0.5191^{a}	5.71
Cash Flow	-0.1704^{b}	-2.90	-0.4416	-0.68
R&D	0.0976	1.66	-2.9071^{a}	-3.96
Acquisition	-0.1300	-1.52	-3.4846^{a}	-4.25
Equity Beta	-0.0701^{a}	-4.66	-2.9175^{a}	-9.21
Stock Price - log	-0.1142^{a}	-3.95	-0.4354	-1.56
Stock Annual Return	-0.1398^{a}	-8.16	-1.3929^{a}	-7.44
Stock Return Volatility	3.0627^{b}	2.28	77.5268^{a}	3.05
Analyst Coverage_res	-0.0607^{a}	-4.55	-0.4069^{a}	-4.79
Inst. Own ($> 5\%$)	0.0196	0.26	-5.2964^{a}	-4.44
Inst. Own ($< 5\%$)_res	-1.3298^{a}	-11.99	-9.9978^{a}	-5.95
Inst. Turnover	0.1396	1.21	-17.9855^{a}	-5.10
IPO2	-0.0005	-0.03	0.4058	1.46
IPO3	-0.0223	-1.26	-0.2806	-1.13
IPO4	-0.0041	-0.26	-0.2101	-0.61
IPO5	-0.0294^{c}	-1.75	-0.2996	-1.48

Short sellers, institutional investors, and corporate cash holdings *

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Abstract

This paper studies the impact of stock short sales on corporate cash holdings. Short sales facilitate the incorporation of negative information into stock prices. Corporate stakeholders, such as capital providers, customers, suppliers, managers and other employees, can infer the negative information from stock prices for their decision making. The actions of short sellers increase the cost of external financing, decrease operational cash flows, and function as a catalyst of firms' financial distress. Corporate cash holdings can serve as the ideal ammunition for the battle with short sellers and as unconditional liquidity support during negative events. Consistent with the precautionary motive of cash holding, this paper finds that short-selling pressure has a positive impact on cash holdings. The results are robust after controlling for relevant firm characteristics, heterogeneity of belief, investors' holding horizons, institutional monitoring incentives, and alternative information channels (such as financial analysts). A test by a simultaneous equation system confirms the causal impact of short sales on cash holdings and excludes the reverse causality. This paper also facilitates a better understanding of short-selling activities in financial markets and provides direct evidence that financial markets have real effects on economy.

Keywords: Short sale, institutional investor, cash holding, corporate stakeholder.
JEL: G14, G23, G32.

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1 Introduction

Short sales facilitate the incorporation of negative information into stock prices (Miller, 1977; Diamond and Verrecchia, 1987), and society can share this negative information through the price system (Hayek, 1945). Corporate stakeholders, such as capital providers, customers, suppliers, managers and other employees, update their relationships with firms based on the information that they have obtained from stock prices (Baumol, 1965; Bond, Goldstein and Prescott, 2010). In a negative event, actions of short sellers exacerbate situations as a catalyst[1] and make firms more likely to suffer from financial distress because of more expensive external financing and lower operational cash flows (Goldstein, Ozdenoren, and Yuan, 2013; Subruhmanyam and Titman, 2001). Furthermore, firms may require liquidity support to combat short sellers (Lamont, 2012). Thus, according to the precautionary motive of cash holdings (Keynes, 1936; Opler, Pinkowitz, Stulz, and Williamson, 1999; Han and Qiu, 2007; Bates, Kahle and Stulz, 2009), short sales should have a positive impact on corporate cash holdings. However, no empirical evidence has been provided for this relationship to date. This paper supplements the literature by empirically examining whether and why short sales in stock markets affect corporate cash holdings.

First, this study demonstrates that short-sale demand has a positive impact on cash holdings. A high short-interest ratio (short interest over shares outstanding) indicates strong demand from short sellers and is a negative signal for a firm's future. In such a situation, managers hoard more cash because they expect higher capital costs, reduced cash flows, and an expensive fight with short sellers. Furthermore, consistent with the precautionary motive of cash holdings, this study offers evidence that the heterogeneity of firm characteristics affects the cash holding sensitivity to short sales. For example, the cash holdings of firms with higher levels of business risk and firms with higher R&D expenses are more sensitive to short-selling activities in the stock market. A multivariate analysis regresses cash holdings on the lagged short-interest ratio and control variables, and the control variables follow Bates, Kahle and Stulz (2009). For robustness purposes, the

[1] See an example of Carson Block and Sino-Forest in Appendix 2.

results of the following three econometric estimators are reported: Fama-MacBeth (1973) estimator, OLS estimator (clustering both firm and year) (Petersen, 2009), and industry and year fixed-effect estimator. All of these estimators demonstrate the consistent and significantly positive impact of short-sale demand on cash holdings.

Second, this study provides evidence that the short-sale constraint reduces precautionary cash holdings. Short-sale constraint is measured through institutional ownership (Asquith, Pathak, and Ritter, 2005; Nagel, 2005) because institutional investors are the main suppliers of equity loans for short sales (D'Avolio, 2002). High levels of institutional ownership indicate a low short-sale constraint, and should lead to greater cash holdings. The empirical evidence verifies the positive impact of institutional ownership. However, there are other potential explanations for this effect. For example, high levels of institutional ownership may signal better corporate governance and increase the value of cash and optimal cash holdings; or active trading by institutional investors may make the stock prices more vulnerable to negative news (Brown, Chen, and Shekhar, 2011). To clarify that the impact of institutional ownership on cash holdings operates because of concerns about short selling, the following tests are done. Firstly, the divergence of opinion among investors is considered. Together with low short-sale constraints (high institutional ownership), significant divergence of opinion indicates strong demand for short-selling and should strengthen the effect on cash holdings. Supportive evidence is provided below. Secondly, to disentangle with the "better governance" explanation ("active trading" explanation) of institutional ownership, blockholder ownership (investors' holding horizon) is controlled, and the impact of institutional ownership on cash holdings remains significantly positive.

Third, this study demonstrates that short selling has a unique impact that is different from alternative information channels. For example, financial analysts make firms' performances more transparent to the public and analysts' preferences can affect corporate policies (Degeorge, Derrien, Kesckes and Michenaud, 2012); market liquidity stimulates trading frenzies in financial markets, which have feedback effects on capital providers and corporate financing (Goldstein, Ozdenoren, and Yuan, 2013; Nyborg and Wang, 2013). Controlling for analyst coverage and stock liquidity, short sales continue to have significant impact on cash holdings.

Fourth, this study investigates the causality in the relationship between short sales and cash holdings through a simultaneous equation system. Theoretically, short sellers should have less interest in a firm with plenty of cash holdings because such a firm has more instruments to protect its stock price. The causality test confirms the short sale's causal impact on cash holdings and rejects reverse causality. Furthermore, the test sheds light on the determinants of short selling in financial markets. The evidence indicates that short sellers tend to target firms with loose stock short-sale constraints, heterogeneous investors' beliefs, volatile performances, fragile capital structures, and weak stakeholder connections.

This paper contributes to the cash holding literature by specifying short sale as a factor that affects precautionary cash holding. Managers should be wary of short-selling activities, or even the potential of short-selling in negative scenarios. In particular, R&D-intensive firms and firms with riskier businesses are more sensitive to short-selling activities because these firms are more vulnerable to short-selling attacks. This paper also contributes to the literature on the real effects of financial markets. It explains how short selling in financial markets affects corporate cash policy; like a catalyst, short sales amplify the effects of negative news, and firms under attack are more likely to suffer from financial distress. Furthermore, this paper facilitates a better understanding of determinants of short-selling activities in financial markets. Short sellers prefer stocks with fewer constraints on short selling, higher heterogeneity of investors' belief, more volatile performance, and weaker stakeholder connections. Finally, this paper suggests that short sellers may play a role in market monitoring (Tirole, 2001) and sheds light on formulating regulations of short selling. Short sellers benefit from the negative events of firms and have strong incentives to dig deeply into the dark side of companies, which affects firm managers' decision making on corporate policies. Short-selling bans may have effects on corporate policies through the feedback effect of financial markets.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and develops the hypotheses. Section 3 describes the data and variables. Section 4 presents the evidence of the demand-side impact of short sales. Section 5 demonstrates how short-sale constraints affect cash holdings. Section 6 presents the robustness check with alternative information channels. Section 7 reports the causality test by a simultaneous

equation system. Finally, Section 8 concludes.

2 Literature review and hypotheses

This study closely relates to three strands of literature: short sales, corporate cash holdings, and the real effects of financial markets. Actions in financial markets can significantly affect real economic activities due to the informativeness of security prices (Bond, Edmans, and Goldstein, 2012). This idea can go back to Hayek (1945). Dow and Gorton (1997) develop a model to demonstrate that information in stock prices affects investment decisions. Subruhmanyam and Titman (1999) demonstrate that the going-public decision is affected by stock price efficiency. There is also empirical evidence for the real effects of financial markets. Chen, Goldstein and Jiang (2007) find that stock price informativeness has strong positive effects on the sensitivity of corporate investment to stock price. Fresard (2012) demonstrates that stock price informativeness has positive effects on cash saving sensitivity to stock price. Edmans, Goldstein, and Jiang (2012) find that stock price has a strongly negative effect on takeover activity. Hau and Lai (2013) find that stock price has a causal effect on corporate investment and employment. Goldstein, Ozdenoren, and Yuan (2013) propose a theoretical model to illustrate trading frenzies in financial markets and their impact on corporate capital providers' decisions.

Short-selling activity in financial markets can improve stock price informativeness by facilitating the incorporation of negative information into stock prices. There is evidence that short sellers own super information, which can be private information or sophisticated analyses based on public news (Engelberg, Reed, and Ringgenberg, 2012) that is not yet incorporated into stock prices. Seneca (1967), Figlewski (1981), Figlewski and Webb (1993), Dechow, Hutton, Meulbroek and Sloan (2001), and Desai, Ramesh, Thiagarajan, and Balachandran (2002) all find evidence that stocks with higher short interest have lower subsequent returns. Christophe, Ferri, and Angel (2004) find evidence of informed trading in pre-announcement short selling. Pownall and Simko (2005) find that short sellers function as information intermediaries covering the lower tail of earnings expectations. Cohen, Diether, and Malloy (2007) find that short-sale demand leads to negative abnormal

returns in the following month and that the short-selling market is an important mechanism for revealing private information. Bris, Goetzmann, and Zhu (2007) find international evidence that short selling facilitates the incorporation of negative information into stock prices. Boehmer, Jones, and Zhang (2008) find evidence that short sellers are well informed and that institutional, nonprogram short sales are the most informative. Karpoff and Lou (2010) find that short sellers anticipate the eventual discovery (and severity) of financial misconduct. Boehmer and Wu (2013) find that short selling stimulates the price discovery process.

A high short interest is a negative signal for a firm, as argued by Diamond and Verrecchia (1987), and triggers additional concerns in financial markets. Furthermore, in practice, after short sellers build up their short positions, they may aggressively spread negative information among corporate stakeholders. For example, based on their research investigations short sellers may publish negative news among investors or in the public media to maximize the impact of negative information on the firm stock prices so that they can make maximal profit quickly. Short-selling attacks can damage relationship with stakeholders that are crucial for a firm's survival and growth (Jensen, 2001; Titman, 1984; Cornell and Shapiro, 1987; Subruhmanyam and Titman, 2001; Fee, Hadlock and Thomas, 2006; Kale and Shahrur, 2007; Banerjee, Dasgupta, and Kim, 2008; Almanzan, Suarez and Titman, 2009; Bushee and Miller, 2012). Clearly, managers should not ignore short sales in the financial markets when making corporate policies.

However, most research on short sales focuses on the relationship between the short sale and stock return, while the impact of short sales on corporate policies has rarely been investigated, with the exception of Grullon, Michenaud, and Weston (2012), who find that an increase in short-selling activity reduces equity financing and investment by lowering stock prices. This paper focuses on the effect of short selling on corporate cash holdings.

A fundamental target in research on cash holding is to understand why firms hold so much cash given the relatively low rate of return. Bates, Kahle and Stulz (2009) demonstrate that on average, US industrial firms more than doubled their cash holdings from 1980 to 2006 and held cash worth more than 20% of their total assets from 2000 to 2006. Corporate cash holdings may be driven by different motives, including transaction

motives (Baumol, 1952; Miller and Orr, 1966; Mulligan, 1997), tax motives (Foley, Hartzell, Titman, and Twite, 2007), agency motives (Jensen, 1986; Dittmar, Mahrt-Smith, and Servaes, 2003; Dittmar and Mahrt-Smith, 2007; Pinkowitz, Stulz, and Williamson, 2006; Harford, Mansi, and Maxwell, 2008; Chava and Purnanandam, 2010; Liu and Mauer, 2011), and precautionary motives.

Firms may have unexpected and urgent liquidity requirements, such as for an investment opportunity requiring quick actions (Huberman, 1984), or corporate crisis management during negative events[2]. However, the external financing may be expensive or perhaps not even available when firms face urgent liquidity support. This concern motivates firms to hold cash. Keynes (1936) describes this motive as precautionary motive. The following studies offer significant support for the precautionary motives for cash holdings. Almazan, Motta, Titman, and Uysal (2010) find firms located within an industry cluster have more acquisition opportunities and maintain more financial slack; Kim, Mauer and Sherman (1998) demonstrate that optimal liquidity increases with the variance of future cash flows; Opler, Pinkowitz, Stulz and Williamson (1999) find that firms with strong growth opportunities and riskier cash flows hold more cash; Almeida, Campello, and Weisbach (2004) find that financially constrained firms have positive cash flow sensitivity of cash; Han and Qiu (2007) show that the cash holdings of financially constrained firms are sensitive to cash flow volatility because of precautionary motives; McLean (2011) finds firms increasingly issue shares for cash savings because of increasing precautionary motives; Bates, Kahle, and Stulz (2009) find that cash holdings increase as cash flows become riskier and that precautionary motives play an important role; and Acharya, Davydenko, and Strebulaev (2012) find that cash savings are positively correlated with credit spreads and that precautionary savings are central to understanding this relation.

The concerns of precautionary motives are further specified in the literature. For example, Acharya, Almeida, and Campello (2007) find that the correlation between future investment opportunities and cash flows affects corporate cash policy. Palazzo (2012)

[2]For example, on Nov. 15, 2011, Sino-Forest released the investigation findings of the Independent Committee to deny the allegation of fraud. The investigation started on the same day of Muddy Waters report. "Taking into account advisor costs, the Company has incurred costs of approximately $35 million to date on the work of the Independent Committee and matters arising as a result of the MW Report"

demonstrates firms with a higher correlation between cash flows and the aggregate shock are more likely to have higher optimal cash savings. Baskin (1987), Haushalter, Klasa, and Maxwell (2007), Fresard (2010), Fresard and Valta (2012), and Hoberg, Phillips and Prabhala (2012) all study the relationship between cash holdings and competition in product markets, and Ruchin (2010) finds that corporate diversification decreases cash savings because of lower cross-divisional correlations in investment opportunities. What is the concern of managers with respect to short selling? The answer is found in the correlation between the distress of negative events and short selling attacks in financial markets. Short sellers chase negative events and attempt to depress stock prices to maximize profits. The negative information spread among stakeholders by short sellers, coupled with a slumping stock price, may deter potential capital providers (Goldstein, Ozdenoren, and Yuan, 2013) or trigger negative domino effects among non-financial stakeholders (Subruhmanyam and Titman, 2001), which exacerbates financial distress as a catalyst in negative events. According to the precautionary motives of cash holdings, managers should hoard more cash when short-selling pressure is high in stock markets.

Furthermore, the heterogeneity of firm characteristics affects the sensitivity of cash holding to short selling. For example, firms with volatile performances tend to have weaker relationships with stakeholder and are more vulnerable to short-selling attacks. Firms with significant business risk might have instruments other than cash to hedge. But in practice, many risks are not hedgeable, thus requiring firms to hold cash (Bates, Kahle and Stulz, 2009). R&D activities may also affect the strength of the short-sale impact. R&D expenditures have increased sharply in recent decades. Brown and Petersen (2011) find that firms use cash reserves to smooth their R&D expenditures because R&D investment is risky and the adjustment cost is high. When a firm in trouble faces financial constraints, it must survive today and suspend investments for the future (e.g. cut R&D expenditures). Moreover, when R&D projects are suspended, previous expenditures would become useless sunk costs. Worse yet, relevant experts performing R&D may move to competitors. Therefore, R&D-intensive firms should be more sensitive to short-selling activity.

In practice, facing attacks from short sellers, firms' blockholders and managers may

choose to fight back. Khanna and Mathews (2012) study the incentives of blockholders to protect the value of their stake from short-selling attacks by trading against short sellers. Lamont (2012) studies the battles between short sellers and firms and posits that "firms use a variety of methods to impede short selling, including legal threats, investigations, lawsuits, and various technical actions intended to create a short squeeze. These actions create short sale constraints." A sufficient amount of cash is a strong signal for financial health, and such resources solidify stakeholder confidence and provide liquidity support to defend stock prices.

The theoretical and empirical research on short sales and cash holdings suggests the following hypothesis:

Hypothesis 1 *Short-selling activity in financial markets has a positive impact on corporate cash holdings; a firm's business risk and R&D expenses strengthen this impact, which is consistent with precautionary motives of cash holdings.*

Short sales are typically implemented under certain constraints, particularly in bearish markets. For example, the uptick rule was introduced in the Securities Exchange Act of 1934 as Rule 10a-1 and implemented in 1938.[3] Almazan, Brown, Carlson and Chapman (2004) find that approximately 70% mutual funds are not allowed to short sell. Miller (1977) proposes that stocks with high divergence of opinions and short-sale constraints tend to be overpriced because only the most optimistic opinions are expressed freely in the pricing. Jones and Lamont (2002), Duffie, Garleanu and Pedersen (2002), Asquith, Pathak and Ritter (2005), Boehme, Danielsen, and Sorescu (2006) and Berkman, Dimitrov, Jain, Koch, and Tice (2009) find that stocks with short-sale constraints have lower subsequent returns. Short sale constraints should alleviate short-sale pressures and weaken the precautionary motives of cash holdings. In literature, institutional ownership is a prevalent measure of fewer short-sale constraints (Asquith, Pathak and Ritter, 2005; Nagel, 2005). Thus, the second hypothesis related to short-sale constraints and cash holdings is as follows:

[3]The SEC eliminated uptick rule on July 6, 2007. However, facing the political and public pressure, the SEC adopted an alternative uptick rule as Rule 201 on Feb. 24, 2010 (SEC release 2010-26).

Hypothesis 2 *Institutional ownership has a positive impact on precautionary cash holdings because high institutional ownership indicates fewer short-sale constraints; moreover, high divergence of investors' opinions strengthens this impact on cash holdings.*

Notably, institutional ownership may affect cash holdings through mechanisms other than short sales. For example, institutional investors may actively monitor corporate management and improve corporate governance. Better governance increases the value of cash (Dittmar and Mahrt-Smith, 2007) and optimal cash holdings. Large institutional shareholders should be the main source of this outside monitoring (Shleifer and Vishny, 1986; Carleton, Nelson, and Weisbach, 1998). Holderness (2003) offers a thorough survey of blockholders in corporate governance. Another explanation for the impact of institutional ownership is related to the active trading of institutional investors. Brown, Chen, and Shekhar (2011) find that ownership by short-term institutions, which trade more frequently, increases corporate cash holdings. These alternative mechanisms will be disentangled from the short-sale mechanism in this study. Thus, the third hypothesis is as follows:

Hypothesis 3 *As a proxy for the supply of short-sale equity loans, institutional ownership has a positive impact on cash holding after controlling for the ownership of blockholders and investors' holding horizons. Furthermore, this positive impact is amplified in firms with relatively more short-term investors because such firms have weaker connections with shareholders and are more vulnerable to short-selling attacks.*

3 Data and variables

The sample in this study includes data from comprehensive sources. Corporate annual accounting data are from CRSP-COMPUSTAT Merged. Daily and monthly stock data are from CRSP. High-frequency intra-day stock data are from TAQ. Short-interest data are from Bloomberg (from 1992). Analysts related information is from IBES. Institutional holding data are from Thomson Reuters (13f). Fama-French factors are from Kenneth

French's website[4]. The sample excludes financial firms (SIC code 6000 to 6999) and utility firms (SIC code 4900 to 4999). Only firms with positive total assets, positive sales, and leverage[5] between 0 and 1 were considered. Only firms with common stocks traded in NYSE, AMEX or NASDAQ were considered. Companies with stock that was traded fewer than 100 days in a fiscal year or that changed exchanges during the year were excluded. Stocks with prices more than US$ 999 per share were excluded. The sample begins in 1992 because of the availability of short-interest data, and the sample ends in 2010.

Cash holding is measured by the ratio of cash and short-term investment (CHE) over the book value of total assets (AT) in each fiscal year[6]. Short sale is studied from both the demand and supply sides. The demand side of short sales is measured by the Short interest-ratio, which is the ratio of short interest over shares outstanding and directly reflects the short-selling activities in the market. Theoretically, short interest describes the intersection of short-sale demand and supply and could not simply be used to measure short demand, i.e., it measures demand only if the supply of short sales is not bound. Fortunately, in practice short-selling constraints are unlikely for the overwhelming majority of stocks, as shown in Asquith, Pathak, and Ritter (2005). In this study, the Short-interest ratio is winsorized at the top percentile each year, which makes it more reliable as a measure of short-sale demand. Furthermore, an extremely high short-interest ratio indicates that the negative event has been very serious and the firm may have consumed the cash holdings but be unable to re-accumulate cash savings at that moment, as described by the suggestive evidence of Goldstein, Ozdenoren, and Yuan (2013). Therefore, the winsorization of Short-interest ratio alleviates the contamination of the relationship between short sales and cash policy caused by firms with extremely high Short-interest ratio. The short-interest data are available in a monthly or semi-monthly frequency[7]. The ratios are first calculated in the corresponding frequency, and the annual Short interest ratio is then calculated as the

[4]http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html. Thanks Fama and French for making the data publicly available.

[5]Total debt divided by total assets (AT), where total debt is long-term debt (DLTT) plus debt in current liabilities (DLC).

[6]The abbreviations in capital letter are the variable names in the dataset CRSP-Compustat Merged.

[7]On March 6, 2007, the SEC approved amendments to Rule 3360 that increase the frequency of short interest reporting from monthly to twice a month. See details in SEC release No. 34-55406. The new rule was effective on September 7, 2007.

average of the monthly or semi-monthly ratios during that fiscal year.

The supply side of short sales is studied through Institutional ownership. The stock is easier to borrow, and short sellers face fewer constraints as the share of stock held by institutional investor increases, ceteris paribus. Institutional ownership is measured by the ratio of shares held by institutional investors over shares outstanding. Institutional ownership is originally calculated as the fraction of shares held by institutions in a quarterly frequency. Institutional ownership above one is not considered. If there is no holding data in Thomson Reuters (13f), the Institutional ownership is set to zero. The annual Institutional ownership is the average quarterly institutional ownership across that fiscal year.

The two remaining variables relevant to institutional investors are Blockholder ownership and Institutional turnover. Blockholder ownership is used to disentangle institutional governance incentives from short-selling concerns. Blockholders are defined as institutions that own more than 5% of a firm's shares. Blockholder ownership is the ratio of total holdings of blockholders over shares outstanding. It is initially calculated at a quarterly frequency and then averaged across the fiscal year for the annual rate. Institutional turnover is a measure for the institutional investment horizon, which is controlled for the effect of institutional trading frequency on cash holdings. The construction of Institutional turnover follows Gaspar, Massa, and Matos (2005) and Yan and Zhang (2009) and details are in Appendix 1.

Two variables are related to financial analysts. One of the variables is the Analyst coverage, which is a proxy for an alternative information source and is calculated as the logarithm of one plus the number of IBES analysts who provide fiscal year one earnings estimates. The other is Divergence of opinion, the analysts' forecasts dispersion following Diether, Malloy, and Scherbina (2002) and Garfinkel (2009). It is calculated as the standard deviation of earnings forecasts scaled by the absolute value of the mean earnings forecast. Both Analyst coverage and Divergence of opinion are initially calculated in each month, and then, the annual variables are obtained by taking the average over that fiscal year.

Two variables are related to firms' cash flow risk. The first is Industry cash flow

volatility, following Bates, Kahle, and Stulz (2009) who denote it as Industry sigma. For each firm-year, compute the standard deviation of cash flow to assets for the previous 10 years; at least three observations are required for the calculations. Industry cash flow volatility is then calculated as the average of firm cash flow standard deviations across each two-digit SIC code. The other variable is Operating income volatility (Zhang, 2006; Berkman, Dimitrov, Jain, Koch, and Tice, 2009; Fang, Noe, and Tice, 2009), which is calculated for each firm in one year as the standard deviation of quarterly operating income before depreciation divided by the quarterly book value of assets across the 20 quarters prior to the fiscal year end. A minimum of eight quarterly observations per firm is required. Firms in the same industry share the identical Industry cash flow volatility, whereas each firm has its own Operating income volatility. However, Industry cash flow volatility is available for more firms than Operating income volatility because of the restriction on the number of observations in the calculations. Following Bates, Kahle and Stulz (2009), Industry cash flow volatility will be used in the basic regressions. Operating income volatility will be used in the tests that emphasize the heterogeneity of firms. In fact, the two measures of cash flow risk have similar effects on cash holdings, which is consistent with precautionary motives for cash holding.

Idiosyncratic risk, also called firm-specific risk, may affect short sellers' decisions. Pontiff (2006) and Duan, Hu, and McLean (2010) find evidence that idiosyncratic risk increases the cost of arbitrage and defers short-selling activity. However, it is also possible that high idiosyncratic risk make a firm more vulnerable to short-selling attacks. It improves short sellers' profit expectations conditional on the negative information. Therefore, idiosyncratic risk is included as a factor that impacts short interest in the simultaneous equation system for the causality test. Following Fu (2009) idiosyncratic risk is estimated by an exponential GARCH model, which is also used by Brockman, Schutte and Yu (2009), Spiegel and Wang (2006), and Eiling (2013), by regressing the monthly stock return on the Fama-French three factors; Idiosyncratic risk is calculated as the square root of the conditional variance of the error term.

Stock liquidity is used to measure how easily information can be spread through stock markets. Nyborg and Wang (2013) find that stock liquidity has a positive impact on

cash holding. Two standard measures of stock liquidity are used in this study. One is Acharya and Pedersen's (2005) modified version of the original Amihud illiquidity measure. Goyenko, Holden, and Trzcinka (2009) suggest that Amihud measure does well as a price impact measure. Following Acharya and Pedersen (2005), the original Amihud measure is revised for concerns regarding the effects of inflation over a long time period and extreme values. It is calculated as follows:

$$Illiq_{i,t} = \min\left(0.25 + 0.30 \cdot Illiq\_Amihud_{i,t} \cdot P_{t-1}^{M},\ 30.00\right),$$

where P_{t-1}^{M} is the ratio of the capitalizations of the market portfolio at the end of the previous fiscal year and of the market portfolio at the end of July 1962. And $Illiq\_Amihud_{i,t}$ in the formula above is the original annual illiquidity measure for firm i in year t as in Amihud (2002):

$$Illiq\_Amihud_{i,t} = \frac{1}{N}\sum_{d=1}^{N}\frac{|r_{i,t,d}|}{DVol_{i,t,d}},$$

where $r_{i,t,d}$ is stock return on day d in year t, $DVol_{i,t,d}$ is the dollar trading volume (in million dollars) on day d in year t, and N is the number of trading days in year t. For stocks in NASDAQ, the trading volume faces double counting and intra-dealer problem. As suggested by Atkins and Dyl (1997) and Nagel (2005b), trading volumes in NASDAQ are adjusted by multiplying 0.5. Furthermore, following Nyborg and Ostberg (2011), exclude the daily CRSP observations with negative price on either day d or $d-1$ and a zero return on day d because this indicates stale prices and spurious volume. Therefore, this liquidity measure is the adjusted version of the original Amihud (2002) measure following Acharya and Pedersen (2005).

The other stock liquidity measure is the logarithm of the relative effective bid-ask spread (Chordia, Roll, and Subrahmanyam, 2001, Fang, Noe, and Tice, 2009) calculated using TAQ. The effective spread is defined as the difference between the execution price and the mid-point of the prevailing bid-ask quote. Then relative effective bid-ask spread is the effective spread divided by the mid-point of the prevailing bid-ask quote.

Using TAQ, the calculation is proceeded in the usual way as follows: to compute the

relative effective bid ask spread, Quotes established before the opening of the market or after the close of the market are excluded. Quotes are also discarded if the offer price is lower than the bid price. The trade record is excluded if it does not have positive a price or trading size. The Lee and Ready (1991) algorithm is then used to match trades and quotes: for a trade between 1993 and 1998, the five-second rule is used; for a trade between 1999 and 2010, the trade is matched to the first quote before the trade. The same matching methodology is used by Chordia, Roll, and Subrahmanyam (2008) and Fang, Noe, and Tice (2009). To eliminate potential errors in trades and quotes, following Chordia, Roll, and Subrahmanyam (2001), after the matching process, the observations which satisfy the following four conditions were excluded:

1. *QuotedSpread* $> \$5$;
2. *EffectiveSpread/QuotedSpread* > 4.0;
3. *RelativeEffectiveSpread/RelativeQuotedSpread* > 4.0;
4. *QuotedSpread/TransactionPrice* > 0.4,

where *RelativeEffectiveSpread* and *EffectiveSpread* are relative effective bid-ask spread and *effective spread* defined above, *QuotedSpread* is the difference between prevailing quoted bid and ask, and the *RelativeQuotedSpread* is *QuotedSpread* divided by the mid-point of the corresponding quoted bid and ask. The daily relative effective bid-ask spread is calculated by taking arithmetic mean of the transaction-level relative effective bid-ask spread on one trading day. The annual relative effective bid-ask spread is the average of daily relative effective bid-ask spread within the corresponding fiscal year. Following Fang, Noe, and Tice (2009), the logarithm of the annual relative effective bid-ask spread (Log_resprd) is used because of the normality concern.

Other control variables follow those in Bates, Kahle and Stulz (2009), including Firm size, Leverage, Market-to-book ratio (MTB), Net equity issuance, Net debt issuance, Cash flow, Net working capital, R&D expenditure, Capital expenditure, Acquisition, Dividend dummy, and IPO dummies. The definitions of these control variables are in Appendix 1.

The sample is winsorized as follows. R&D, Acquisition, Capital expenditure, and Industry cash flow risk are winsorized on both sides at 1%. Equity beta[8] is winsorized on both sides at 0.5%. Net working capital and Cash flow are winsorized from bottom at 1%. MTB and Short-interest ratio are winsorized from top at 1%. It leaves 31,545 firm-years observations.

Insert Table 1 here.

Table 1 reports the statistics of the variables in the sample. The sample period is from 1992 through 2010. An average firm in the sample holds cash that measures up to 19% of its total assets, which is consistent with the high cash ratios presented in Bates, Kahle, and Stulz (2009). The median of short interest is 1%, and the institutional ownership medians are many-fold greater than the short interest medians. These findings are consistent with those of Asquith, Pathak and Ritter (2005) and justify the short-interest ratio as an appropriate proxy for short-sale demand.

Insert Table 2 here.

Table 2 presents the correlation matrix of variables. The correlation between Cash ratio and Short-interest ratio is significantly positive, with a Pearson correlation of 0.16 and a Spearman rank correlation of 0.21. These results are consistent with the precautionary motives of cash holdings. The correlation coefficients between Cash ratio and certain firm characteristics, including Firm size, Leverage, MTB, Industry cash flow risk, Net equity issuance, R&D, Net working capital, Capital expenditure, Acquisition, Dividend dummy and IPO dummies, are consistent with the findings in Bates, Kahle, and Stulz (2009). Table 2 indicates negative correlations between cash ratio and Institutional ownership, Net debt issuance, and Analyst coverage. These counter-intuitive correlations may be caused by hidden firm characteristics, such as Firm size. As a stylized fact, cash holding is negatively associated with firm size. Moreover, Institutional ownership, Net debt issuance, and Analyst coverage are positively correlated with firm size, as shown in Table 2. Therefore, those correlations may not reflect the actual relations between Cash

[8]Annual Scholes-Williams (1977) equity beta is downloaded from CRSP. Equity beta will be used in the causality test as a regressor for Short interest ratio in equation (4).

and Institutional ownership, Net debt issuance, and Analyst coverage. In the following sections, the relationship between cash holdings and relevant factors will be investigated through multivariate regression analysis.

4 Short interest: the demand side of short sales

This section studies the relationship between cash holdings and short-sale demand, which is measured by Short-interest ratio. A high Short-interest ratio indicates the short sellers' intense attention and is a negative signal to the firm. Managers can learn from this signal and must concern themselves with how stakeholders' reactions affect stock prices and firm business operations. For example, a high short-interest ratio may trigger the concerns of rating agencies and loan providers, which would affect the cost of debt financing; suppliers may become reluctant to provide trade credit, and potential customers may reconsider whether they should buy products. Corporate policies, such as the cash policy, may be affected by the short interest in the market. Consistent with precautionary motives of cash holdings, Short-interest ratio should have a positive impact on cash holdings, as posited in Hypothesis 1.

4.1 Basic regressions

The first part of Hypothesis 1 is tested by the following specification.

$$\begin{aligned} Cash\ ratio_{i,t} \;=\; & Intercept + Short\ interest\ ratio_{i,t-1} + Firm\ size_{i,t} + Leverage_{i,t} \\ & + MTB_{i,t} + Industry\ cash\ flow\ risk_{i,t-1} + Net\ equity\ issuance_{i,t} \\ & + Net\ debt\ issuance_{i,t} + Cash\ flow_{i,t} + Net\ working\ capital_{i,t} \\ & + R\&D_{i,t} + Capital\ expenditure_{i,t} + Acquisition_{i,t} \\ & + Dividend\ dummy_{i,t} + IPO\ dummies_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where i refers to a firm and t refers to a year. Both Short-interest ratio and Industry cash flow risk are lagged for one year to address the precautionary motives for cash holding and the endogeneity concern.

Insert Table 3 here.

The regression results are provided in columns (2) to (4) in Table 3. Three different estimators are used for robustness purpose. Column (2) presents the results of Fama-MacBeth (1973) estimator. The t-values in Fama-MacBeth estimators are calculated based on Newey-West (1987) standard errors. Column (3) provides the results of OLS clustering in both firm and year dimensions. The t-values for the firm-year clustered estimator are based on the two-dimensional standard error proposed in Petersen (2009). Column (4) provides the results of the firm and industry fixed-effects estimator. The t-values for the industry-year fixed effects estimator are adjusted for heteroskedasticity by firm cluster, and Fama-French 48-industry categories are used for industry classification.

The impact of the short-interest ratio is positively significant and consistent in all three estimators. On average, a 1% increase in the Short-interest ratio in the market from the previous year results in an approximately 0.44% increase in Cash ratio. Relatively, if the Short-interest ratio increases from the first quartile to the third quartile, the Cash ratio increases by 1.5%.[9] The coefficients of the control variables, such as Firm size, Leverage, Net working capital, Net debt issuance, Net equity issuance, are all consistent with the results in Bates, Kahle, and Stulz (2009)[10].

4.2 Further evidence: operating income volatility and R&D expenses

The heterogeneity of firm characteristics can affect the impact of short-selling activity on cash holdings, as stated in the second part of Hypothesis 1. One characteristic is firm's business risk, which is measured by Operating income volatility. Firms with riskier business are more likely to have extreme cash flows. Therefore, a negative signal is more likely to indicate an extreme loss. Learning from the negative signal sent by short sellers, corporate

[9] The first quartile of Short-interest ratio is 0.002 and the third quartile is 0.035. Then $1.5\% \approx \left[\frac{1}{3} \cdot (0.469 + 0.435 + 0.425)\right] \times (0.035 - 0.002)$.

[10] The only exception is Industry cash flow risk in industry and year fixed effect estimator. The coefficient is still positive but not significant. The reason is that Industry cash flow risk is defined at an industry level, whereas industry dummies absorb the effect and make the industry level risk measure insignificant.

stakeholders, such as capital providers, suppliers, and customers, have less confidence in the firm's performance and are more likely to weaken or even terminate their relationships with the firm. Thus this concern must strengthen the firm's precautionary motives for cash holding. The other firm characteristic is R&D expense. Successful R&D projects generate investment opportunities and help the firm maintain a competitive advantage among peers. Liquidity shortages will make R&D-intensive firms suffer considerably because the previous expenses becomes sunk cost and expert researchers may move to competitors.

To test the amplifying effect of firm business risk (R&D expense), the intersection term between Operating income volatility (R&D) and Short-interest ratio is added on the right side of Specification (1):

$$\begin{aligned} Cash\ ratio &= Intercept + Amplifier \times Short\text{-}interest\ ratio + Amplifier \\ &\quad + Short\text{-}interest\ ratio + Controls + \epsilon, \end{aligned}$$

where *Amplifier* is *Operating income volatility* or *R&D*. The intersection term $Amplifier \times$ *Short-interest ratio* is expect to be significantly positive.

The results of the tests are presented in Columns (5) to (10) of Table 3. Columns (5) to (7) are the results for Operating income volatility, and Columns (8) to (10) are the results for R&D. In Columns (5) to (7), the coefficients of the intersection term *Operating income volatility* $\times$ *Short-interest ratio* are all significantly positive. The amplifying effect is also economically meaningful. For example, in the Fama-MacBeth (1973) estimator, if the Operating income volatility increases from the first quartile to the third quartile, the impact of Short-interest ratio is amplified by 40.2%.[11] This evidence strongly supports the hypothesis that short-selling activities affect cash holding through the precautionary motive of cash holding.

Columns (8) to (10) in Table 3 demonstrate that the coefficients of the intersection term *R&D* $\times$ *Short-interest ratio* are all significantly positive, which indicates that firms' R&D expenses amplify the impact of short selling on cash holdings. In the Fama-MacBeth

[11]The first quartile of Operating income volatility is 0.01 and the third quartile is 0.03. The amplifying effect $40.2\% \approx 7.543 \times (0.03 - 0.01)/(0.300 + 7.543 \times 0.01)$. Correspondingly, the firm and year cluster estimator shows the amplifying effect as 42.9% and the fixed-effect estimator shows the amplifying effect as 42.5%.

(firm and year clustered OLS, industry and year fixed-effects) estimator, when the R&D expense increases from the first quartile (0.00) to the third quartile (0.06), the impact of short selling on cash holdings is amplified by 31.8% (38.0% and 34.6%, respectively).

This section presents the supportive empirical results for the test of Hypothesis 1. The evidence indicates that short-sale demand in the market has a positive impact on corporate cash holdings, particularly for firms that are vulnerable to negative information. High-business-risk and R&D-intensive firms are more fragile regarding short-selling activity in the market, leading the cash holdings of these firms to be more sensitive to short selling.

5 Institutional ownership: the supply side of short sales

This section studies the relationship between cash holdings and short-sale constraints, which is measured by Institutional ownership. Higher Institutional ownership indicates fewer short-sale constraints which leads to higher cash holdings as posited in Hypothesis 2.

When managers see the real threats from short sellers in the market, it is intuitive for them to accumulate more cash, as demonstrated in the previous section. The concern about short selling may not be limited to the actual short sale demand. When the cash policy is formulated, precautionary motives make firms prepare cash savings for future negative scenarios. The supposed negative scenarios may not currently be a real problem, and the short sellers may not have started their attacks, which means that short interest in the market may not be high at the time. However, short sellers have strong motivations to expose negative information about firms, and they tend to appear very quickly after negative events start. The difficulty in negative scenarios is likely to be underestimated if the role of short sellers is ignored. Therefore, when making cash policy, it is reasonable to consider the impact of possible short sales in negative scenarios. As the supply of equity loan increases, there will be fewer short constraints, and more aggressive short-selling attacks.

Before testing Hypothesis 2, the relationship between cash holding and short-sale demand-supply is intuitively illustrated as follows. First, divide the firms into four by four groups based on the demand and supply of short sales independently, and then, calculate the average cash ratios within each group of demand-supply combination.

Note that Firm size is highly correlated with both Institutional ownership and Cash ratio. The correlation between Firm size and Institutional ownership is 0.43 and correlation between Firm size and Cash ratio is -0.37. Grouping the firms by institutional ownership would be similar to grouping by Firm size; the relationship between cash holding and institutional ownership would be distorted because high institutional ownership is expected to have a positive impact cash holding, whereas the size effect on cash holding may hide this impact. To purge the size effect, Institutional ownership is de-sized and the residual is used in grouping. The de-sizing procedure follows Nagel (2005).[12] To be consistent, the same procedure is also run for Short-interest ratio even if the size effect may not be a concern for it. In each year, the firms are divided into 16 groups by the respective quartile breakpoints of lagged residual Institutional ownership and lagged residual Short-interest ratio.

Insert Table 4 here.

Table 4 presents the average Cash ratios of these 16 groups. The table demonstrates clear increasing trends of Cash ratios along both the demand and supply dimensions. Given the demand for short sale, high supply of equity loans loosens short-sale constraints, and potential threats from short sellers are high. It strengthens the precautionary motive of cash holdings, particularly for firms with high Short-interest ratios. In the top quartile group of the Short-interest ratio, Cash ratio is monotonically increasing along the supply dimension. And the average Cash ratio in the top quartile of Institutional ownership is 8.5% higher than that in the bottom quartile. In fact, differences of means between the

[12]Firstly, Institutional ownership (*Inst. Own.*) is mapped from an interval between zero and one to the real line by a logit transformation: $logit(Inst.\ Own.) = log\left(\frac{Inst.\ Own.}{1-Inst.\ Own.}\right)$, where values of Institutional ownership below 0.0001 and above 0.9999 are replaced with 0.0001 and 0.9999 respectively. Secondly, regress the truncated Institutional ownership on Firm size and square of Firm size in each year to get the residual institutional ownership. The square term of Firm size is set to capture the nonlinear relation between Institutional ownership and Firm size.

top and bottom quartile groups are all significantly positive, as shown in Column "*4-1*" with corresponding t-statistics. Similarly, given the supply of equity loans for short sales, the increasing trend along columns illustrates that Cash ratios increase with short-sale demand in the market, which is consistent with the results in the previous section.

5.1 Baseline regressions

The first part of Hypothesis 2 is tested by the following specification.

$$\begin{aligned} Cash\ ratio_{i,t} &= Intercept + Inst.\ Own._{i,t-1} + Firm\ size_{i,t} + Leverage_{i,t} \\ &\quad + MTB_{i,t} + Industry\ cash\ flow\ risk_{i,t-1} + Net\ equity\ issuance_{i,t} \\ &\quad + Net\ debt\ issuance_{i,t} + Cash\ flow_{i,t} + Net\ working\ capital_{i,t} \\ &\quad + R\&D_{i,t} + Capital\ expenditure_{i,t} + Acquisition_{i,t} \\ &\quad + Dividend\ dummy_{i,t} + IPO\ dummies_{i,t} + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

where $Inst.\ Own._{i,t-1}$ refers to the institutional ownership of firm i in previous year. The lagged Institutional ownership is used to capture precautionary motives for cash holding and alleviate the endogeneity concern. As posited in Hypothesis 2, the coefficient of $Inst.\ Own._{i,t-1}$ is expected to be significantly positive, which indicates the positive effect of short-sale supply on cash holdings.

Insert Table 5 here.

Table 5 presents the regression results. Columns (2) to (4) are the Fama-MacBeth, firm and year clustered OLS, and industry and year fixed-effect estimators of Specification (2). The coefficients of $Inst.\ Own._{i,t-1}$ are all significantly positive, as expected. The average coefficient of the three estimators is 0.063, which indicates that if Institutional ownership increases from the first quartile to the third quartile, the Cash ratio increases by 3.3%.[13] The coefficients of the control variables are consistent with those in Bates, Kahle, and Stulz (2009). To observe how the demand and supply of short sales compete for the effects on cash holdings, the lag of Short-interest ratio, which was used as a proxy

[13]The first quartile of *Institutional ownership* is 0.186, and the third quartile is 0.707. Then $3.3\% \approx (0.707 - 0.186) \times 0.063$.

for short-sale demand in the previous section, is added to the right side of Specification (2). The regression results are presented in Columns (5) to (7) of Table 5.

The coefficients of Institutional ownership and Short-interest ratio are all significantly positive. These results indicates that both the real threats of short sales in the market and the potential threats in future negative scenario have a positive effect on precautionary cash holdings. The coefficients of Institutional ownership become slightly smaller than the corresponding coefficients in Columns (2) to (4) in Table 5. Similarly, the coefficients of Short-interest ratio also become a little smaller than those in Columns (2) to (4) in Table 3, in which only the demand of short sales is considered, which indicates that the effect on cash holdings is shared by the concern of the real short sale threats and the potential for short-sale threats. When comparing the coefficients of Institutional ownership and Short-interest ratio, we can observe that the absolute effect of the real threat of short sales in the market is approximately nine times as strong as that of potential threats, which indicates that firms react much more seriously to short-selling pressure in the market than to the potential threat in the "imagined" negative scenarios. However, in practice the value of Institutional ownership is much larger than that of Short-interest ratio. According to the results in Columns (5) to (7) in Table 5, if Institutional ownership increases from the first quartile to the third quartile, Cash ratio increases by 2.24%; in contrast, if Short interest ratio increases from the first quartile to the third quartile, Cash ratio increases only 1.24%, which indicates that the effect of the short-sale supply is not as weak as it may appear.

Divergence of opinion measures the difference between pessimistic and optimistic investors. High divergence of opinion indicates that pessimistic investors have strong motives to short sell the stock. As stated by the second part of Hypothesis 2, high divergence of option should strengthen the impact of short-sale supply on cash holdings. This part of Hypothesis 2 is tested by the following specification.

$$\begin{aligned} Cash\ ratio_{i,t} &= Intercept + Inst.\ Own._{i,t-1} \times Div.\ Op.\ Dum._{i,t-1} \\ &\quad + Inst.\ Own._{i,t-1} + Div.\ Op.\ Dum._{i,t-1} + Controls + \epsilon_{i,t}, \end{aligned}$$

where the dummy variable *Div. Op. Dum.* takes a value of one for Divergence of opinion

in the top quartile, and a value of zero for Divergence of opinion in the bottom quartile. The control variables are identical to those in Specification (2). Both *Inst. Own.* and *Div. Op. Dum.* are lagged to capture the precautionary motives of cash holdings. The coefficient of the intersection term $Inst.\ Own._{i,t-1} \times Div.\ Op.\ Dum._{i,t-1}$ is the key indicator for the test. A positive coefficient of the intersection term supports that Divergence of opinion amplifies the effect of Institutional ownership on Cash ratio because of concerns about short sales.

Insert Table 6 here.

Table 6 presents the results. Columns (2) to (4) provide the coefficients in the Fama-MacBeth, firm and year clustering, and industry and year fixed-effects estimators respectively. All coefficients of the intersection term are significantly positive, which indicates that the effect of Institutional ownership on Cash ratio is stronger for firms with higher Divergence of opinion. For example, in the Fama-MacBeth estimator, the effect of Institutional ownership on Cash ratio in the top quartile of Divergence of opinion is three time greater than in bottom quartile[14], which strongly supports the second part of Hypothesis 2.

5.2 Alternative explanations: governance incentives and investors' holding horizons

There are other explanations for why institutional ownership may affect cash policies. For example, high institutional ownership may lead to better governance because institutions may be actively involved in corporate governance. Better governance improves the value of cash and might increase the optimal amount of cash holdings. As we know, not all institutional investors actively monitor firms. For example, small shareholders may be free-riders in corporate governance, and only large shareholders have strong incentives to monitor the firms. To disentangle the possible "better governance" effect from the "short-sale threat" effect, Blockholder ownership is controlled as a proxy for institutional

[14]For firms in top quartile of Divergence of opinion, the effect of Institutional ownership is (0.045+0.021=0.066), while in bottom quartile the effect is only 0.021.

governance incentives. A blockholder is defined as an institutional investor who holds at least 5% of a firm's shares. Blockholder ownership is the sum of holdings of all blockholders divided by share outstanding. The specification is as follows.

$$Cash\ ratio_{i,t} = Intercept + Inst.\ Own._{i,t-1} + Block.\ Own._{i,t-1} + Other\ Controls + \epsilon_{i,t},$$

where $Block.\ Own.$ refers to Blockholder ownership and $Other\ Controls$ includes the same variables as the control variables in Specification (2). The regression results are listed in Columns (5) to (7) in Table 6. The coefficients of $Inst.\ Own.$ in all estimators continue to be significantly positive after Blockholder ownership is controlled, which directly supports Hypothesis 3. However, the coefficients of $Block.\ Own.$ are all insignificant at the 10% level, which does not support the argument that stronger governance incentive increases cash holdings. One possible reason for this result is that the appearance of blockholders indicates their strong connection with firms. During negative events, firms can rely on supports from blockholders because it would be much more painful for blockholders to sell their shares than for small shareholders. This intuition may ease the precautionary motives of cash holding.

Another explanation for why institutional ownership affects cash policy relates to institutional trading activity. Institutional investors are professional and can actively rebalance their portfolios in financial markets. However, intensive trading activity may make stock prices more volatile, thus requiring firms to hold more cash because external financing can be more expensive. However, not all institutional investors trade actively. For example, short-term investors may hold the stocks for speculative purpose and trade the stocks more frequently, whereas long-term investors may hold stocks for expected benefits from the increase in firm value over the long run. To disentangle the "active-trading" mechanism, the institutional investors' holding horizon is considered in the analysis. The specification is as follows.

$$\begin{aligned} Cash\ ratio_{i,t} \;=\; & Intercept + Inst.\ Own._{i,t-1} + Dum.\ Short\text{-}term\ inv._{i,t-1} \\ & + Other\ Controls + \epsilon_{i,t}, \end{aligned}$$

where *Dum. Short-term inv.* is a dummy variable, which takes a value of one for firms with Institutional turnover above the median, and a value of zero for the remaining firms. *Other Controls* includes the same variables as the control variables in Specification (2).

Furthermore, a firm with relatively more short-term investors tends to have weaker relationship with its shareholders. When such a firm faces an attack from short sellers, it is more likely to be abandoned by its shareholders, which indicates that short-sale threats are intensified in such firms, as stated in Hypothesis 3. The specification is as follows.

$$\begin{aligned} Cash\ ratio_{i,t} &= Intercept + Inst.\ Own._{i,t-1} \times Dum.\ Short\text{-}term\ inv._{i,t-1} \\ &\quad + Inst.\ Own._{i,t-1} + Dum.\ Short\text{-}term\ inv._{i,t-1} \\ &\quad + Other\ Controls + \epsilon_{i,t}, \end{aligned}$$

The key indicator of the specification is the intersection term $Inst.\ Own. \times Dum.\ Short\text{-}term\ inv.$, and a positive coefficient is expected for the amplification effect.

Columns (8) to (10) in Table 6 present the test results for the active-trading mechanism in Hypothesis 3. The coefficients of $Inst.\ Own.$ are significantly positive in all three estimators after *Dum. Short-term inv.* is controlled in the regressions, which is consistent with Hypothesis 3. Moreover, the coefficients of *Dum. Short-term inv.* are also significantly positive in all three estimators, which supports the argument that shorter investment horizons have a positive impact on cash holdings. These results indicate that both short-sale supply and investment horizon positively affect cash holdings but through different dimensions of precautionary motives. Columns (11) to (13) provide the test results for the amplification effect in Hypothesis 3. The coefficients of intersection term $Inst.\ Own. \times Dum.\ Short\text{-}term\ inv.$ are all significantly positive, which strongly supports the amplification effect in Hypothesis 3. For example, in the Fama-MacBeth estimator, the effect of short-sale supply on cash holdings of firms with relatively more short-term investors is 1.65 times of that for remaining firms.

6 Robustness test: Alternative information channels

This section investigates whether short-sale activity has unique impact on cash holdings compared to other information channels. Stock liquidity facilitates the release of new information and increases price informativeness, because it can lower transaction costs or weaken the price impact of trading activities (Holmstrom and Tirole, 1993; Chordia, Roll and Subrahmanyam, 2008; Collin-Dufresne and Fos, 2012). Stock liquidity strengthens the firms' concern for negative events and has a positive impact on cash holdings (Nyborg and Wang, 2013). Another information channel is through financial analysts. A higher analyst coverage means that firm's performance is more transparent to the public, which may affect corporate policies (Graham, Harvey and Rajgopal, 2005; Chang, Dasgupta, and Hilary, 2006; Yu, 2008; Dyck, Morse, Zingales, 2010; Chang, 2011; Chen, Harford, and Lin, 2012). Thus, it might be possible that these factors have similar effects on corporate policies because they facilitate the diffusion of information regarding the same firms.

Compared to these two information channels, short selling has a special feature in information diffusion because it particularly facilitates the spread of *negative* information, which is essential to the precautionary motives of cash holdings. Negative information owned by insiders may spread slowly. For example, insiders may own private information but may be reluctant or not allowed to benefit by trading on negative information. There may also be concerns regarding to the role of financial analysts. The agency problem of analysts can lead to positive biases in their recommendations or earning forecasts (Dugar and Nathan, 1995; Lin and McNichols, 1998; Michaely and Womack, 1999; Hong and Kubik, 2003). In this section, a survival test is conducted. The specification for the race is as follows.

$$\begin{aligned} Cash\ ratio_{i,t} &= Intercept + Short\ insterest\ ratio_{i,t-1} + Stock\ liquidity_{i,t-1} \\ &\quad + Analyst\ coverage_{i,t-1} + Controls + \epsilon_{i,t}, \end{aligned}$$

where stock liquidity is measured by adjusted Amihud illiquidity or by the logarithm of the relative effective bid-ask spread (Log_resprd), and *Controls* refer to the identical control variables in Specification (1). To address the collinearity concern with firm size,

following Nyborg and Wang (2013), stock liquidity measures and analyst coverage are also residualized with respect to Firm size in each year. Results of tests with both initial and residualized stock liquidity and analyst coverage are illustrated in Table 7.

Insert Table 7 here.

Columns (2) to (7) provide the results for the original liquidity measures and analyst coverage. Columns (8) to (13) provide the results for the residual liquidity measures and residual analyst coverage, which alleviates the collinearity concern. The coefficients of *Short insterest ratio* are all significantly positive at the 1% level. This result is robust to different econometric methodologies, different stock liquidity measures, and the concern for collinearity, which indicates that short selling successfully survives in the test and has its unique effect on cash holdings. Moreover, all coefficients of illiquidity are significantly negative, which indicates that stock liquidity has a positive impact on cash holdings, consistent with the findings of Nyborg and Wang (2013). The result for analyst coverage is similar. All of the coefficients for analyst coverage are positive, which is consistent with the argument that high analyst coverage makes firms more transparent to the public and strengthens the precautionary motives of cash holdings.

The results in Table 7 demonstrate that these information channels have their own special effects on corporate policy and cannot be entirely substituted by each other. Because new information can spread from these channels among stakeholders, managers must consider the effect of these information channels when making corporate policies, such as investment, financing, and cash policies. Managers are thus better monitored, which is consistent with the monitoring roles of financial markets and financial analysts.

7 Causality test: simultaneous equation system

This section addresses the endogeneity concern through a simultaneous equation system of cash holding and short sale. Endogeneity is an important issue in empirical research (Roberts and Whited, 2012). The evidence in previous sections might be challenged by reserve causality, i.e., it might be that cash holding affects short selling and not vice versa.

However, it appears unlikely that short sellers target firms with a large amount of cash. A high cash ratio indicates that the firm is financially healthy. With sufficient liquidity support, the firm has more options in defending its stock price against short-selling attacks, which makes short sales more expensive and riskier. An alternative argument might be the free cash flow problem (Jensen, 1986) because a high cash ratio might trigger the concern that managers could waste the money in value-decreasing projects. However, it is better for short sellers to act when the firm is spending its cash holdings inefficiently. The cash holding is then consumed and the short sellers are thus actually targeting firms with less cash.

In previous sections, the endogeneity concern is alleviated by using the lagged value of short-sale proxies. In this section, further evidence for the causality is shown by the following simultaneous equation system.

$$Cash\ ratio_t = \alpha_0 + \boldsymbol{\alpha_1} Short\text{-}interest\ ratio_t + \sum_{j=2} \alpha_j X_{j,t-1} + \eta_t \quad (3)$$

$$Short\text{-}interest\ ratio_t = \beta_0 + \boldsymbol{\beta_1} Cash\ ratio_t + \sum_{k=2} \beta_k Z_{k,t-1} + \xi_t \quad (4)$$

where X_j represents control variables in Equation (3) in which Cash ratio is the dependent variable, and Z_k represents control variables in Equation (4) in which Short-interest ratio is the dependent variable. To test the endogeneity of cash holding and short selling, contemporaneous values are used for Cash ratio and Short-interest ratio, and lagged values are used for control variables. Considering the effect of industry, the Fama-French 48-industry dummies are controlled in both equations of the system, but the coefficients of industry dummies are not reported here. The key indicators of the causality test are the signs and significance of $\boldsymbol{\alpha_1}$ and $\boldsymbol{\beta_1}$, which are the coefficients of Short-interest ratio and Cash ratio, respectively.

The control variables in Equation (3), X_j's, includes the controls in Specification (1) with Industry cash flow risk replaced by Operating income volatility. The control variables in Equation (4), Z_k's, require some explanation. In Equation (4), Short-interest ratio represents the actual short-selling in the stock markets. When short sellers look for a target,

they must consider the cost or constraints of their short sales. Therefore, institutional ownership is controlled as a proxy for short-selling constraints from the equity loan supply. Stock liquidity may also affect the cost of short selling because short sellers sell first and buy later to repay the shorted stock. Heterogenous beliefs may affect Short-interest ratio (Figlewski, 1981). A high heterogeneity of beliefs with short-sale constraints leads to overpricing (Miller, 1977). Given the constraint level for a stock, higher heterogeneity of beliefs may link to more serious overpricing, which stimulates more short-selling demand and leads to a higher Short-interest ratio. Divergence of opinion is used as a proxy for heterogeneity of beliefs, and measured by the coefficient of variation of the analyst earning forecast. Equity beta measures the systematic risk of the stocks. Both speculative motive and hedging motive indicate that short sellers may prefer stocks with higher equity betas (McDonald and Baron, 1973).

Idiosyncratic risk is also a concern of short sellers. Short sellers may avoid targeting stocks with high idiosyncratic risk because of the difficulty of hedging and the limits of arbitrage (Shleifer and Vishny, 1997). However, stakeholders tend to have less faith in stocks with high idiosyncratic risk and the prices of such stocks are more vulnerable to negative information, which may cause short sellers to prefer these stocks. Therefore, Idiosyncratic risk is controlled. Total return volatility reflects the general stability of stock returns. Stocks with more volatile returns tend to be more sensitive to negative events and more likely to be targeted by short sellers. Stock returns may affect the short-interest ratio. If short sellers believe the return follows a mean-reverting process, they may target stocks with high past returns (Hurtado-Sanchez, 1978). Thus, annualized stock return in the previous year is controlled. Analyst coverage may affect short selling as analysts make the firm more transparent to public. Short sellers are sophisticated investors, and can better infer valuable information from public sources (Engelberg, Reed, and Ringgenberg, 2012). Thus, Analyst coverage is added. Certain firm characteristics may affect short-selling activity. For example, young growth firms tend to have weaker relationships with stakeholders, and it is therefore easier for short sellers to trigger negative cascades as proposed by Subruhmanyam and Titman (2001). Thus, firm age and market to book ratio (MTB) are added. Firms with high leverage have less stable capital structures, and are

more likely to become a target of short sellers. High cash flows indicate a healthy business; thus, these firms are less likely to be attacked by short sellers. So Leverage and Cash flow are included. The entire list of control variables can be found in Table 8.

The simultaneous equation system is estimated following the procedure in Chordia, Huh, and Subruhmanyam (2007). In each year, a two-stage least squares (2SLS) estimator is calculated for the system. Then, the time-series average of the coefficients is taken as the final estimator for the system. Table 8 reports the results. *Panel A* presents the coefficients for Equation (3), in which Cash ratio is the dependent variable. *Panel B* presents the coefficients for Equation (4), in which Short-interest ratio is the dependent variable. The coefficients are provided in the second column, and the t-statistics are provided in the third column. The t-statistics are calculated based on Newey and West (1987) standard errors.

Insert Table 8 here.

In *Panel A* of Table 8, the coefficient of Short-interest ratio ($\boldsymbol{\alpha_1}$) is significantly positive at the 1% significance level. This result strongly supports the hypothesis that short sales have a positive impact on cash holdings. Moreover, *Panel B* shows that the coefficient of Cash ratio ($\boldsymbol{\beta_1}$) is not significant at the 10% level, which indicates that cash holding has no significant effect on short sales. When short sellers target a firm, contemporaneous cash holding does not appear to be a crucial consideration. The causality test clearly indicates that short sales cause cash holding, and that the reverse causality is not true.

The coefficients of other variables in the system also include useful information. In *Panel A*, the coefficients are consistent with stylized facts in the cash literature. For example, Firm size, Leverage and Capital expenditure all have negative effects on cash holding, whereas MTB, R&D, and Operating income volatility all have positive effects on cash holding. However, the coefficient of Net equity issuance is positive but not significant, which indicates that the equity issuance in the previous year does not have a significant impact on current cash holdings. The proceedings from equity issuances have a positive impact on the cash holding in the same year, as shown in previous sections. But firms tend to spend the proceedings in the following year. Compared to the significantly positive

coefficient of Net debt issuance, firms appear to accumulate cash by issuing debt rather than by issuing equity, which is consistent with the pecking order theory (Myers, 1984; Myers and Majluf, 1984).

Panel B of Table 8 illustrates the factors affecting short-selling activity in the market. Which firms are more likely to be targeted by short sellers? The results in *Panel B* provide partial answers. Short sellers prefer stocks with fewer constraints on short selling, higher heterogeneity of investors' belief, more volatile performance, and weaker stakeholder connections. These features can either decrease the direct cost of short-selling activities, or amplify the impact of negative events. Thus, short sellers expect a higher payoff from their attacks. For example, *Panel B* demonstrates that Institutional ownership and stock liquidity both have positive effects on short selling, which indicates that short sellers prefer stocks with higher equity loan supply and lower transaction costs. The coefficient of Divergence of opinion is significantly positive, which indicates that higher heterogeneity of investors' belief leads to more short sales.

The coefficients of Equity beta, Idiosyncratic risk, and Return volatility are all significantly positive. Equity beta measures systematic risk, Idiosyncratic risk represent undiversifiable risk, and Return volatility is for total risk of stock returns. Short sellers enjoy these risks because these features predict more extreme losses during negative events. Although idiosyncratic risk may increase the risk of short positions, higher expected payoff from short sales dominates short sellers' decision making. After all, short sellers are typically not investors with high risk aversion. Stock returns in the previous year have no observable impact on short selling, which indicates that on average short sellers are not momentum investors. They have private information about firms' future, which has not been incorporated into stock prices. However, the significantly negative coefficient of Cash flow indicates that firms with good business performance in the previous year are less likely to be shorted.

The coefficient of Firm age is significantly negative and the coefficient of MTB is significantly positive, which is consistent with the idea that young and growth firms are more likely to be targeted by short sellers because they generally have weaker connections with their stakeholders. The coefficient of Leverage is significantly positive, which indicates that

short sellers prefer firms with fragile capital structures. In a negative event, highly leveraged firms are more likely to go bankrupt. As the owners of residual claims, stockholders may rush to escape and cause stock prices to dive. The coefficient of Analyst coverage is not significant, which indicates that on average short sellers tend to acquire negative information from channels other than financial analysts. All these findings indicate that short sellers prefer stocks with lower short selling cost, and stocks that are more vulnerable to negative events.

In sum, in this section, the causality test is performed using a simultaneous equation system. The results strongly support the hypothesis that short-selling activities cause more precautionary cash holdings, and that the reverse causality is not true. Endogenizing short selling does not appear to change other major conclusions from the single-equation estimation. Furthermore, the results in *Panel B* facilitate a better understanding of short-selling activities in financial markets.

8 Conclusions

This paper studies the relationship between stock short sales and corporate cash policy. Consistent with the precautionary motive of cash holding, the study finds that short-sale pressure has a positive effect on cash holdings. The fundamental mechanism relies on stock price informativeness and the importance of a firm's relationship with its stakeholders. Short sellers have strong motivation to search and release negative information about firms, which facilitates the transfer of negative information to stock prices. Stakeholders learn the negative information, which tends to weaken the relationship with the firms in trouble. Short sales function as a catalyst for firms' financial distress in negative events, which makes the firms more likely to suffer from liquidity shortages and strengthens the precautionary motives for cash holdings.

This study provides the evidence that both the actual threat of stock short sales and the potential supply for short sales increase cash holdings. Cash holdings in firms with riskier business and more R&D investment are more sensitive to short sellers' attack. Alternative information channels are controlled, and the impact of short sales remains significant. The

causality of the relationship is supported by the simultaneous equation system test, which also sheds light on the understanding of short selling activities in financial markets. Further research could study how short sales affect other corporate polices. Because managers consider short sales when making corporate policies, the monitoring role of short sellers also deserves further investigation.

Appendix 2: Carson Block versus Sino-Forest.

Carson Block, the short seller who founded Muddy Waters Research, earned his reputation for short selling Chinese stocks traded in North America. In 2011, Block targeted Sino-Forest Corporation, one of the leading commercial forest plantation operators in China. Sino-Forest was traded on the Toronto Stock Exchange (TRE) with a market capitalization of US$ 4.63 billion as of June 1, 2011. On June 2, the short seller announced his attack through a report by Muddy Waters Research. The report alleged Sino-Forest an "established institutional fraud". On June 3, the stock price of Sino-Forest plunged 71.5% compared to the price one day before the report. US$ 3.3 billion in shareholders' wealth evaporated. The attack by the short seller triggered tremendous concerns among investors. Paulson & Co., which held a 14.1% stake as of April 29, 2011, disposed its entire stake as of June 17, 2011 with a loss of US$720 million[15]. Sino-Forest denied the allegation of fraud. However, the situation became increasingly worse in a domino effect. Rating agencies downgraded its long-term corporate credit rating. Asset sales could not find potential buyers. The Chinese government was less supportive of the company and withheld timber cutting licenses[16]. Its relationships with customers and suppliers became strained[17]. On August 26, 2011, the Ontario Securities Commission suspended the shares of Sino-Forest. On March 30, 2012, Sino-Forest sued Muddy Waters Research and Carson Block. On the same day, Sino-Forest filed for bankruptcy. On May 22, 2012, the Ontario Securities Commission filed charges of fraud against the Sino-Forest Corporation and five of its former executives.

In the case of Sino-Forest, the short seller built up a short position, and then aggressively spread negative information to depress the stock price. The slump of the stock price triggered serious concerns of stakeholders, such as capital investors, governments, customers and suppliers. The firm failed to quell the worries of stakeholders. Finally, it

[15]http://www.bloomberg.com/news/2011-06-21/paulson-dumping-sino-forest-may-deal-clients-720-million-loss.html

[16]http://www.bloomberg.com/news/2012-04-02/sino-forest-peek-made-buyers-run-away-corporate-canada.html

[17]In the release of bankruptcy filing on March 30, 2012, Judson Marin, the vice-Chairman and CEO of Sino-Forest said "We believe the full value of our assets will only be achieved if we are able to continue operating the business, and **repair and preserve relationships with our customers and suppliers**."

was abandoned by the stakeholders and went to bankrupt.

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Appendix 1: Descriptions of variables

The names of variables in COMPUSTAT are shown in parentheses.

Variable	Descriptions
Acquisition	The ratio of acquisition expenditures (AQC) relative to total book assets (AT).
Analyst coverage	Take average of the number of analysts covering the firm across months within a fiscal year. Then take logarithm of one plus the average. If a stock is not covered in IBES, set the Analyst coverage to zero.
Blockholder ownership	Total proportion of shares outstanding held by institutional investors with more than 5% of shares outstanding each.
Cash flow	[EBITDA (OIBDP) − interest (XINT) − taxes (TXT) − common dividends (DVC)]/total assets (AT).
Capital expenditure	The ratio of capital expenditures (CAPX) to the book value of total assets (AT).
Cash ratio	The ratio of cash and short-term investment (CHE) to the book value of total assets (AT).
Divergence of opinion	Coefficient of variation of EPS one-year forecasts by finanacial analysts in IBES.
Dividend dummy	A dummy variable equal to one if a firm paid common dividend (DVC) in that year; zero otherwise.
Equity beta	Annual Scholes-Williams beta available from CRSP.
Firm age	Calculate the number of months since a stock first appears in CRSP. Then take logarithm of one plus the number of months.
Operating income volatility	Standard deviation of quarterly operating income before depreciation divided by quarterly book value of assets across 20 quarters prior to the fiscal year end. Minimum of eight quarterly observations per firm are required.
Firm size	Logarithm of total assets, where the total assets are deflated to 1980 dollars.
Idiosyncratic risk	Calculated by an EGARCH model following the procedure of Fu (2009).
Industry cash flow risk	The mean of the standard deviations of Cash flow over 10 years for firms in the same industry (2-digit SIC code), at least 3 firm-year observations required. It follows the variable Industry Sigma in Bates, Kahle, and Stulz (2009).
Illiq	Acharya and Pedersen's (2005) revised version of the original Amihud (2002) illiquidity: $Illiq_{i,t} = \min(0.25 + 0.30 \cdot Illiq\_Amihud_{i,t} \cdot P^M_{t-1},\ 30.00)$, where P^M_{t-1} is the ratio of the capitalizations of the market portfolio at the end of the previous fiscal year and of the market portfolio at the end of July 1962, $Illiq\_Amihud_{i,t} = \frac{1}{N}\sum_{d=1}^{N} \frac{\lvert r_{i,t,d}\rvert}{DVol_{i,t,d}}$, $r_{i,t,d}$ is stock return on day d in year t, $DVol_{i,t,d}$ is the dollar trading volume (in million dollars) on day d in year t, and N is the number of trading days in year t. Trading volumes in NASDAQ are adjusted by multiplying 0.5.

Continued on next page

Appendix – continued from previous page

Variable	Descriptions
Institutional turnover	First, calculate institutional churn ratio following Yan and Zhang (2009): $\text{Churn Ratio}_{k,t} = \frac{\min(\text{Churn\_buy}_{k,t}, \text{Churn\_sell}_{k,t})}{\sum_{i=1}^{N_k}(S_{k,i,t}P_{i,t} + S_{k,i,t-1}P_{i,t-1})/2}$, where N_k is the total number of stocks in the portfolio of institution k, $S_{k,i,t}$ is the share number of stock i held by institution investor k in quarter t, $P_{i,t}$ is the price of stock i in quarter t, $\text{Churn\_buy}_{k,t} = \sum_{i=1,\ S_{k,i,t}>S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\text{Churn\_sell}_{k,t} = \sum_{i=1,\ S_{k,i,t}\le S_{k,i,t-1}}^{N_k} \lvert S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}\rvert$, $\Delta P_{i,t}$ is the change of price as $P_{i,t} - P_{i,t-1}$. Second, following Gaspar, Massa, and Matos (2005), Institutional turnover is calculated as $\sum_{k\in\mathcal{S}} w_{i,k,t}\left(\frac{1}{4}\sum_{r=1}^{4}\text{Churn Ratio}_{k,t-r+1}\right)$, where $\mathcal{S}$ is the set of institutional shareholders of stock i, and $w_{i,k,t}$ is the weight of investor k in the total percentage held by institutional investors in year-quarter t. Then an annual Institutional turnover is calculated as the average across a year.
Institutional ownership	Total proportion of shares outstanding held by institutional investors in 13F.
IPO2 ∼ IPO5	Dummy variables equal to one if the firm went public 2 to 5 years ago respectively.
Leverage	Total debt divided by total assets (AT), where total debt is long-term debt (DLTT) plus debt in current liabilities (DLC).
Log_resprd	Logarithm of relative effective bid-ask spread. Relative effective bid-ask spread is the difference between the execution price and the mid-point of the prevailing bid-ask quote divided by the mid-point of the prevailing bid-ask quote.
MTB	[Book value of total assets (AT) − book value of equity (CEQ) + market value of equity (PRCC_F× CSHO)]/book value of total assets (AT).
Net debt issuance	[Annual total debt issuance (DLTIS) − debt retirement (DLTR)]/the book value of total assets (AT).
Net equity issuance	[Equity sales (SSTK)− equity purchases (PRSTKC)]/the book value of total assets (AT).
Net working capital	[Net working capital (WCAP) − cash and short-term investment (CHE)]/total assets (AT)
R&D	The ratio of research and development expense (XRD) to total assets (AT). If XRD is missing then set R&D to 0.
Stock return, annualized	Stock return annualized from monthly stock returns in CRSP.
Stock return volatility	Standard deviation of daily stock return within a fiscal year.

Table 1
Descriptive statistics

This table reports the number of firm-year observations, mean, standard deviation, median, minimum and maximum values of corresponding variables in the sample. The sample period is from 1992 through 2010, except the variable Log_resprd that is based on data from *TAQ* and starts from 1993*. The detailed definitions of variables are listed in Appendix 1 and the criteria for sample construction are described in the *Data and variables* section.

	N	Mean	Std. Dev.	Median	Std. Err.	Min	Max
Cash ratio	31545	0.19	0.21	0.10	0.0012	0.00	0.99
Short-interest ratio	31240	0.03	0.04	0.01	0.0002	0.00	0.33
Institutional ownership	30882	0.45	0.29	0.45	0.0017	0.00	1.00
Firm size	31545	4.74	1.95	4.62	0.0110	-0.13	11.63
Leverage	31545	0.20	0.19	0.16	0.0011	0.00	1.00
MTB	31545	1.94	1.42	1.50	0.0080	0.23	29.70
Ind. cash flow volatility	31545	0.09	0.04	0.08	0.0002	0.02	0.19
Idiosyncratic risk	27328	0.15	0.07	0.14	0.0004	0.03	1.29
Divergence of opinion	20001	0.18	0.36	0.05	0.0026	0.00	3.70
Institutional turnover	31284	0.27	0.10	0.25	0.0006	0.00	1.38
Illiq	31545	8.07	11.63	0.99	0.0655	0.25	30.00
Log_resprd*	30326	-5.35	1.32	-5.27	0.0076	-9.17	-1.49
Analyst coverage	31545	1.32	1.01	1.32	0.0057	0.00	3.89
Net equity issuance	31545	0.03	0.16	0.00	0.0009	-1.73	2.18
Net debt issuance	31545	0.00	0.10	0.00	0.0006	-4.31	1.22
Operating inc. vol.	27397	0.02	0.03	0.02	0.0002	0.00	0.74
R&D	31545	0.05	0.09	0.00	0.0005	0.00	0.85
Cash flow	31545	0.04	0.16	0.07	0.0009	-1.51	1.07
Net working capital	31545	0.11	0.18	0.09	0.0010	-0.67	0.92
Capital expenditure	31545	0.06	0.06	0.04	0.0003	0.00	0.45
Acquisition	31545	0.02	0.06	0.00	0.0003	0.00	0.44
Dividend dummy	31545	0.30	0.46	0	0.0026	0	1
IPO2	31545	0.06	0.23	0	0.0013	0	1
IPO3	31545	0.05	0.23	0	0.0013	0	1
IPO4	31545	0.05	0.22	0	0.0012	0	1
IPO5	31545	0.05	0.21	0	0.0012	0	1

Table 2

Correlations

This table reports the pairwise correlations. Lower triangle is for Pearson correlation, and upper triangle is for Spearman rank correlation. The sample period is from 1992 through 2010, except the variable Log_resprd that is based on data from *TAQ* and starts from 1993.

	Cash	SI	IO	Size	Lev.	MTB	ICFR	FBR	IdR	DO	ITO	Ailliq	LRES	AC	NEI	NDI	RD	CF	NWC	CapX	Acq	Div	IPO2	IPO3	IPO4	IPO5
Cash ratio	1	0.21	-0.01	-0.33	-0.56	0.36	0.38	0.38	0.44	0.15	0.21	0.08	0.00	-0.03	0.17	-0.03	0.52	-0.12	-0.17	-0.27	-0.20	-0.30	0.03	0.04	0.03	0.04
Short-interest ratio	0.16	1	0.51	0.14	-0.02	0.09	0.09	0.07	0.19	0.11	0.20	-0.30	-0.44	0.19	0.05	0.01	0.08	-0.06	-0.09	-0.13	0.01	-0.12	-0.04	-0.04	-0.04	-0.02
Institutional ownership	-0.07	0.39	1	0.43	0.07	0.02	-0.02	-0.26	-0.20	-0.16	0.02	-0.51	-0.62	0.34	-0.15	0.00	-0.05	0.13	-0.03	-0.09	0.18	0.09	-0.07	-0.12	-0.09	-0.06
Firm size	-0.37	0.02	0.43	1	0.40	-0.06	-0.19	-0.47	-0.57	-0.23	-0.29	-0.86	-0.71	0.62	-0.29	0.05	-0.22	0.11	-0.16	0.09	0.24	0.44	-0.07	-0.14	-0.13	-0.10
Leverage	-0.42	0.02	0.05	0.31	1	-0.32	-0.24	-0.29	-0.27	0.01	-0.08	-0.13	-0.07	0.08	-0.08	0.10	-0.34	-0.10	-0.11	0.14	0.14	0.16	0.00	-0.01	-0.02	-0.02
MTB	0.38	0.06	-0.02	-0.11	-0.26	1	0.25	0.17	0.05	-0.26	0.07	-0.28	-0.23	0.23	0.10	0.03	0.30	0.34	-0.10	0.03	-0.02	0.01	0.01	-0.01	0.01	0.02
Ind. cash flow risk	0.40	0.06	-0.02	-0.16	-0.19	0.23	1	0.22	0.32	0.12	0.12	0.05	-0.01	-0.01	0.16	-0.01	0.50	-0.11	-0.10	-0.23	0.01	-0.24	0.02	0.03	0.02	0.02
Operating income vola.	0.38	0.08	-0.23	-0.34	-0.16	0.19	0.23	1	0.48	0.34	0.25	0.31	0.30	-0.18	0.23	-0.02	0.24	-0.09	-0.03	0.01	-0.26	-0.31	0.03	0.09	0.10	0.08
Idiosyncratic risk	0.44	0.16	-0.26	-0.52	-0.16	0.11	0.28	0.40	1	0.36	0.45	0.46	0.34	-0.28	0.33	-0.03	0.28	-0.19	-0.08	-0.17	-0.17	-0.64	0.04	0.08	0.09	0.08
Divergence of opinion	0.08	0.05	-0.12	-0.14	0.05	-0.11	0.05	0.14	0.18	1	0.16	0.29	0.27	-0.16	0.19	-0.07	0.13	-0.41	-0.15	-0.03	-0.22	-0.26	0.03	0.04	0.05	0.05
Institutional turnover	0.24	0.15	-0.04	-0.32	-0.04	0.10	0.12	0.24	0.41	0.07	1	0.18	0.15	-0.13	0.27	0.01	0.09	-0.03	-0.07	-0.03	-0.07	-0.39	0.07	0.11	0.08	0.07
Illiq	0.01	-0.24	-0.41	-0.41	-0.01	-0.15	0.00	0.12	0.19	0.13	0.04	1	0.84	-0.71	0.23	-0.06	0.04	-0.24	0.15	-0.09	-0.20	-0.39	0.08	0.15	0.13	0.10
Log_resprd	0.06	-0.30	-0.63	-0.71	-0.02	-0.15	-0.03	0.22	0.31	0.19	0.16	0.55	1	-0.56	0.23	-0.04	0.01	-0.18	0.15	0.04	-0.21	-0.31	0.08	0.15	0.13	0.10
Analyst coverage	-0.04	0.10	0.32	0.55	0.02	0.17	0.01	-0.13	-0.23	-0.12	-0.15	-0.32	-0.51	1	-0.15	0.08	0.01	0.19	-0.16	0.15	0.11	0.21	-0.04	-0.07	-0.06	-0.05
Net equity issuance	0.28	0.00	-0.19	-0.23	-0.08	0.13	0.15	0.29	0.24	0.07	0.22	0.05	0.21	-0.12	1	-0.09	0.17	-0.21	0.01	-0.04	-0.06	-0.27	0.05	0.08	0.07	0.07
Net debt issuance	-0.01	0.03	0.01	0.06	0.21	0.01	0.00	0.00	-0.02	-0.05	0.01	-0.04	-0.04	0.06	-0.09	1	-0.02	-0.05	-0.02	0.11	0.20	0.03	0.00	0.02	0.01	0.00
R&D	0.60	0.08	-0.13	-0.32	-0.26	0.29	0.43	0.34	0.35	0.09	0.17	0.07	0.12	-0.02	0.25	-0.02	1	-0.17	-0.04	-0.27	-0.05	-0.19	0.01	0.01	0.01	0.01
Cash flow	-0.36	-0.05	0.20	0.24	-0.02	0.06	-0.21	-0.27	-0.28	-0.16	-0.11	-0.16	-0.21	0.16	-0.39	-0.05	-0.51	1	0.12	0.37	0.05	0.10	-0.03	-0.05	-0.04	-0.02
Net working capital	-0.26	-0.08	-0.05	-0.16	-0.14	-0.10	-0.13	-0.13	-0.13	-0.08	-0.08	0.05	0.16	-0.13	-0.05	-0.02	-0.19	0.18	1	-0.07	0.03	0.06	-0.04	-0.03	-0.03	-0.01
Capital expenditure	-0.24	-0.05	-0.08	0.02	0.11	-0.01	-0.16	0.02	-0.08	0.00	0.02	0.00	0.07	0.10	-0.01	0.13	-0.18	0.21	-0.14	1	-0.14	0.11	0.03	0.02	0.02	0.00
Acquisition	-0.16	-0.01	0.09	0.07	0.11	-0.05	0.00	-0.10	-0.05	-0.08	0.00	-0.06	-0.08	0.02	0.00	0.34	-0.07	0.06	0.00	-0.12	1	0.10	-0.02	-0.03	-0.02	-0.03
Dividend dummy	-0.31	-0.13	0.11	0.44	0.09	-0.05	-0.21	-0.24	-0.54	-0.17	-0.36	-0.17	-0.31	0.19	-0.17	0.02	-0.27	0.15	0.06	0.02	0.02	1	-0.05	-0.13	-0.12	-0.11
IPO2	0.05	-0.02	-0.08	-0.07	0.01	0.02	0.02	0.04	0.04	0.01	0.07	0.07	0.09	-0.04	0.08	0.01	0.05	-0.07	-0.04	0.03	0.00	-0.05	1	-0.03	-0.03	-0.03
IPO3	0.07	-0.02	-0.13	-0.14	0.00	0.02	0.02	0.11	0.09	0.02	0.11	0.10	0.16	-0.07	0.09	0.03	0.06	-0.09	-0.03	0.03	0.01	-0.13	-0.03	1	-0.06	-0.06
IPO4	0.06	-0.02	-0.09	-0.12	-0.01	0.03	0.02	0.11	0.08	0.02	0.08	0.07	0.13	-0.06	0.07	0.01	0.05	-0.06	-0.02	0.03	-0.01	-0.12	-0.03	-0.06	1	-0.06
IPO5	0.05	0.00	-0.07	-0.10	-0.01	0.03	0.01	0.05	0.08	0.03	0.07	0.05	0.10	-0.05	0.05	0.01	0.03	-0.02	-0.01	0.01	-0.02	-0.11	-0.03	-0.06	-0.06	1

Table 3

Short-interest ratio regressions

This table reports the impact of Short-interest ratio on Cash ratio. Short-interest ratio is calculated as the ratio of short interest over total shares outstanding. The sample is winsorized at the 99^{th} percentile of Short-interest ratio in each year. For the endogeneity concern and precautionary motive of cash holdings, the lagged Short-interest ratio is used in regressions. Columns (2), (3) and (4) show the regressions of basic specification $Cash\ ratio_{i,t} = Intercept + Short\text{-}interest\ ratio_{i,t-1} + Controls + \varepsilon_{i,t}$, where the control variables follows those in Bates, Kahle and Stulz (2009). Further tests are shown in Columns (5) to (10). Columns (5), (6) and (7) are for the test whether cash holdings of firms with higher Operating income volatility are more sensitive to the short-selling pressure, and the specification is $Cash\ ratio_{i,t} = Intercept + Short\text{-}interest\ ratio_{i,t-1} \times Operating\ income\ volatility_{i,t-1} + Short\text{-}interest\ ratio_{i,t-1} + Operating\ income\ volatility_{i,t-1} + Controls + \xi_{i,t}$. Columns (8), (9) and (10) are for the test whether cash holdings of firms with higher R&D are more sensitive to short-selling pressure, and the specification is $Cash\ ratio_{i,t} = Intercept + Short\text{-}interest\ ratio_{i,t-1} \times R\&D_{i,t} + Short\text{-}interest\ ratio_{i,t-1} + R\&D_{i,t} + Controls + \eta_{i,t}$. For each specification in this table, three different estimators are shown: Fama-MacBeth (1973) estimator (FM), OLS estimator clustering on both firm and year dimensions (Cluster2), and industry and year fixed effect estimator (FE). The t-values in Fama-MacBeth estimators are calculated based on Newey and West (1987) standard errors with 2 lags. The t-values in firm-year clustered estimator is based on the 2-dimensional standard error proposed in Petersen (2009). The t-values in industry and year fixed effect estimators are adjusted for heteroskedasticity by firm cluster and Fama-French 48-industry categories are used for industry classification. All t-values are in parentheses under corresponding coefficients. Statistical significance at the 1%, 5% and 10% level are indicated by ***, **, and * respectively.

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Short-interest ratio, lagged	**0.469*** **	**0.435*** **	**0.425*** **	0.300***	0.261***	0.252***	0.375***	0.329***	0.326***
	(8.42)	**(8.89)**	**(9.65)**	(5.75)	(5.05)	(4.50)	(9.73)	(7.16)	(7.11)
Operating inc. vol.				0.156***	0.168*	0.127			
				(3.06)	(1.70)	(1.21)			
Short-int. ratio × Op. inc. vol.				**7.543*** **	**7.122*** **	**6.795*** **			
				(5.38)	**(4.56)**	**(4.27)**			
R&D	0.537***	0.559***	0.434***	0.532***	0.564***	0.440***	0.497***	0.502***	0.384***
	(12.66)	(14.05)	(11.37)	(11.93)	(13.96)	(10.72)	(14.85)	(12.93)	(9.28)
Short-int. ratio×R&D							**1.954*** **	**2.049*** **	**1.846*** **
							(3.24)	**(3.10)**	**(3.35)**
Firm size	-0.010***	-0.009***	-0.011***	-0.009***	-0.009***	-0.010***	-0.010***	-0.009***	-0.011***
	(-9.93)	(-6.62)	(-8.89)	(-10.13)	(-6.49)	(-7.98)	(-9.56)	(-6.55)	(-8.86)
Leverage	-0.362***	-0.359***	-0.357***	-0.353***	-0.350***	-0.349***	-0.363***	-0.361***	-0.358***
	(-19.80)	(-20.50)	(-27.67)	(-22.47)	(-19.79)	(-25.48)	(-20.11)	(-20.68)	(-27.82)
MTB	0.022***	0.020***	0.018***	0.020***	0.019***	0.018***	0.022***	0.020***	0.018***
	(10.69)	(8.79)	(11.14)	(10.78)	(8.35)	(10.14)	(10.6)	(8.83)	(11.20)
Industry cash flow risk, lagged	0.353***	0.404***	0.068	0.286***	0.340***	0.063	0.347***	0.397***	0.053
	(13.62)	(7.05)	(0.87)	(11.10)	(6.18)	(0.79)	(13.12)	(6.90)	(0.68)
Net equity issuance	0.151***	0.153***	0.145***	0.140***	0.151***	0.142***	0.151***	0.154***	0.147***
	(7.07)	(7.98)	(9.73)	(5.22)	(6.23)	(8.73)	(7.06)	(8.13)	(9.86)
Net debt issuance	0.301***	0.260***	0.254***	0.314***	0.267***	0.262***	0.302***	0.259***	0.253***
	(9.81)	(6.30)	(6.94)	(11.22)	(5.36)	(6.06)	(9.80)	(6.33)	(6.95)
Cash flow	-0.019	-0.027	-0.026*	-0.002	-0.015	-0.018	-0.018	-0.026	-0.026*
	(-0.97)	(-1.16)	(-1.70)	(-0.11)	(-0.67)	(-1.07)	(-0.94)	(-1.13)	(-1.66)
Net working capital	-0.304***	-0.309***	-0.341***	-0.297***	-0.303***	-0.332***	-0.304***	-0.309***	-0.340***
	(-27.19)	(-21.91)	(-22.40)	(-25.55)	(-19.98)	(-19.79)	(-26.56)	(-21.85)	(-22.40)

Continued on next page

Table 3 – continued from previous page

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital expenditure	-0.705***	-0.689***	-0.621***	-0.708***	-0.693***	-0.629***	-0.707***	-0.691***	-0.621***
	(-18.42)	(-17.83)	(-19.02)	(-19.11)	(-16.97)	(-17.76)	(-18.00)	(-17.78)	(-19.08)
Acquisition	-0.507***	-0.484***	-0.466***	-0.499***	-0.479***	-0.466***	-0.508***	-0.485***	-0.467***
	(-16.67)	(-13.52)	(-17.25)	(-19.02)	(-12.41)	(-14.92)	(-16.77)	(-13.45)	(-17.28)
Dividend dummy	-0.026***	-0.026***	-0.02***	-0.023***	-0.023***	-0.017***	-0.026***	-0.026***	-0.020***
	(-9.02)	(-5.48)	(-4.76)	(-7.61)	(-4.97)	(-3.95)	(-8.77)	(-5.48)	(-4.74)
IPO2	0.027***	0.028***	0.032***	0.026***	0.029***	0.030***	0.027***	0.029***	0.033***
	(5.10)	(3.89)	(6.77)	(3.05)	(2.87)	(4.57)	(4.96)	(4.01)	(6.96)
IPO3	0.010*	0.011*	0.015***	0.011**	0.011*	0.015***	0.011*	0.012*	0.016***
	(1.91)	(1.81)	(3.39)	(2.15)	(1.75)	(3.07)	(1.96)	(1.93)	(3.55)
IPO4	0.005	0.005	0.009**	0.006**	0.005	0.010**	0.005*	0.005	0.009**
	(1.67)	(0.95)	(1.99)	(2.22)	(1.05)	(2.13)	(1.80)	(1.05)	(2.06)
IPO5	0.000	0.002	0.004	0.002	0.002	0.005	0.000	0.002	0.004
	(-0.03)	(0.55)	(0.93)	(0.36)	(0.67)	(1.09)	(-0.09)	(0.70)	(1.03)
Intercept	0.278***	0.274***	0.317***	0.274***	0.268***	0.306***	0.281***	0.277***	0.320***
	(48.43)	(24.65)	(23.94)	(42.17)	(21.79)	(20.41)	(47.18)	(24.99)	(24.10)
R^2_{adj}	0.54	0.54	0.55	0.54	0.54	0.56	0.54	0.54	0.55

Table 4

Cash ratios across short selling demand-supply groups

In each year, the firms are divided into 4×4 groups by lagged residual Institutional ownership and lagged residual Short-interest ratio independently, using quartile breakpoints. For each of these 16 subgroups, the averaged cash ratios are presented in the table. The residuals of Institutional ownership and Short-interest ratio are used to purge the effect of Firm size. The procedure to calculate the residuals follows Nagel (2005), in which the target variable is regressed on firm size and square of firm size in each time period. The one-year lag is used to capture the precautionary motive of cash holdings and alleviate the edogeneity concern. The mean differences between boundary groups are shown along each dimension. The t tests (with unequal variances) are run for the means of these boundary groups, and the t-statistics of these tests are reported in parentheses.

		Institutional ownership					
		1 (low)	*2*	*3*	*4* (high)	*4−1*	(t-statistics)
Short-interest ratio	*1* (low)	0.116	0.125	0.144	0.183	0.067	(9.73)
	2	0.133	0.127	0.143	0.162	0.029	(4.34)
	3	0.161	0.161	0.171	0.209	0.048	(6.38)
	4 (high)	0.212	0.241	0.273	0.297	0.085	(10.66)
	4−1	0.096	0.116	0.129	0.114		
	(t-statistics)	(13.88)	(15.11)	(16.81)	(14.45)		

Table 5
Institutional ownership regressions

This table reports the impact of short sale supply on corporate cash holdings. Institutional ownership is used as a proxy of equity loan supply for short sales, and the lagged Institutional ownership is used in regressions for precautionary motive of cash holdings and endogeneity concern. Columns (2) to (4) demonstrate the results for the basic specification $Cash\ ratio_{i,t} = Intercept + Inst.\ Own._{i,t-1} + Controls + \varepsilon_{i,t}$. In Columns (5) to (7), Short-interest ratio is added in: $Cash\ ratio_{i,t} = Intercept + Inst.\ Own._{i,t-1} + Short\text{-}interest\ ratio_{i,t-1} + Controls + \eta_{i,t}$. For each specification in this table, three different estimators are shown: Fama-MacBeth (1973) estimator (FM), OLS estimator clustering on both firm and year dimensions (Cluster2), and industry and year fixed effect estimator (FE). The t-values in FM are calculated based on Newey and West (1987) standard errors. The t-values in Cluster2 is based on the 2-dimensional standard error proposed in Petersen (2009). The t-values in FE are adjusted for heteroskedasticity by firm cluster. Fama-French 48-industry categories are used for industry classification. All t-values are in parentheses under corresponding coefficients. Statistical significance at the 1%, 5% and 10% level are indicated by ***, **, and * respectively.

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Institutional ownership	0.057***	0.064***	0.067***	0.041***	0.039***	0.048***
	(7.93)	(7.52)	(7.53)	(7.29)	(4.35)	(5.05)
Short-interest ratio				0.407***	0.366***	0.357***
				(7.45)	(6.27)	(7.16)
Firm size	-0.013***	-0.014***	-0.016***	-0.014***	-0.013***	-0.016***
	(-8.54)	(-7.93)	(-10.80)	(-10.88)	(-8.20)	(-10.77)
Leverage	-0.354***	-0.352***	-0.348***	-0.357***	-0.354***	-0.352***
	(-21.12)	(-20.57)	(-26.79)	(-20.90)	(-20.59)	(-27.02)
MTB	0.022***	0.020***	0.019***	0.022***	0.020***	0.018***
	(10.88)	(9.21)	(11.44)	(11.34)	(8.97)	(11.04)
Ind. cash flow risk	0.352***	0.395***	0.085	0.354***	0.393***	0.082
	(12.75)	(6.71)	(1.08)	(13.54)	(6.79)	(1.04)
Net equity issuance	0.163***	0.165***	0.159***	0.159***	0.163***	0.155***
	(7.99)	(8.61)	(10.56)	(7.32)	(8.38)	(10.29)
Net debt issuance	0.302***	0.262***	0.255***	0.301***	0.261***	0.255***
	(10.30)	(6.49)	(6.92)	(10.33)	(6.34)	(6.83)
R&D	0.530***	0.549***	0.421***	0.524***	0.546***	0.418***
	(12.31)	(13.74)	(11.01)	(11.98)	(13.55)	(10.94)
Cash flow	-0.028	-0.036	-0.034**	-0.023	-0.031	-0.031*
	(-1.48)	(-1.52)	(-2.17)	(-1.33)	(-1.33)	(-1.95)
Net working capital	-0.309***	-0.316***	-0.349***	-0.309***	-0.314***	-0.348***
	(-28.51)	(-22.66)	(-22.71)	(-28.18)	(-22.11)	(-22.58)
Capital expenditure	-0.701***	-0.689***	-0.619***	-0.706***	-0.687***	-0.625***
	(-19.17)	(-18.06)	(-18.85)	(-18.71)	(-17.70)	(-18.90)
Acquisition	-0.522***	-0.504***	-0.482***	-0.519***	-0.495***	-0.478***
	(-16.86)	(-14.44)	(-17.63)	(-16.08)	(-13.88)	(-17.38)
Dividend dummy	-0.029***	-0.029***	-0.023***	-0.026***	-0.026***	-0.020***
	(-7.74)	(-5.81)	(-5.37)	(-8.43)	(-5.22)	(-4.69)
IPO2	0.028***	0.030***	0.033***	0.030***	0.031***	0.035***
	(4.73)	(3.96)	(6.96)	(4.91)	(4.15)	(7.28)
IPO3	0.010*	0.011*	0.015***	0.01	0.011*	0.015***
	(1.78)	(1.73)	(3.31)	(1.72)	(1.73)	(3.23)
IPO4	0.007**	0.006	0.01**	0.006*	0.005	0.009**
	(2.84)	(1.13)	(2.28)	(2.01)	(1.03)	(2.01)
IPO5	0.002	0.003	0.006	0.001	0.003	0.005
	(0.58)	(1.03)	(1.31)	(0.20)	(0.88)	(1.04)
Intercept	0.279***	0.278***	0.320***	0.281***	0.279***	0.324***
	(45.74)	(24.77)	(23.92)	(45.00)	(24.51)	(24.22)
R^2_{adj}	0.54	0.54	0.55	0.54	0.54	0.56

Table 6

Institutional ownership, divergence of opinion, blockholder ownership, and investment horizon

This table illustrates further evidence for the impact of short sale supply on corporate cash holdings. Institutional ownership is used as the proxy of equity loan supply for short sales, and the lagged value is used for precautionary motive of cash holdings and endogeneity concern. Columns (2) to (4) are for the test whether Divergence of opinion can amplify the impact of short sale supply on cash holdings. The specification is $Cash\ ratio_{i,t} = Intercept + Inst.\ Own._{i,t-1} \times Div.\ Op.\ Dum._{i,t-1} + Inst.\ Own._{i,t-1} + Div.\ Op.\ Dum_{i,t-1} + Controls + \epsilon_{i,t}$, where *Div. Op. Dum* is a dummy variable that takes value 1 for top quartile of Divergence of opinion and value 0 for bottom quartile of Divergence of opinion. Divergence of opinion is calculated as the dispersion of analysts' earnings forecasts following Diether, Malloy, and Scherbina (2002). Columns (5) to (7) are for the test of governance motivation of institutional investors by controlling Blockholder ownership. Columns (8) to (10) are for the institutional trading impact on cash holdings by controlling the investment horizon (*Dum. Short-term inv.*). Columns (11) to (13) are for the test whether short-term investors can amplify the impact of short sale on cash holdings. For each specification in this table, three different estimators are shown: Fama-MacBeth (1973) estimator (FM), OLS estimator clustering on both firm and year dimensions (Cluster2), and industry and year fixed effect estimator (FE). The t-values in FM are calculated based on Newey and West (1987) standard errors. The t-values in Cluster2 is based on the 2-dimensional standard error proposed in Petersen (2009). The t-values in FE are adjusted for heteroskedasticity by firm cluster. Fama-French 48-industry categories are used for industry classification. All t-values are in parentheses under corresponding coefficients. Statistical significance at the 1%, 5% and 10% level are indicated by ***, **, and * respectively.

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Inst.Own.×Div.Op.Dum.	**0.045*** **	**0.055*** **	**0.057*** **									
	(3.04)	**(2.77)**	**(3.26)**									
Inst. Own.	0.021*	0.026*	0.020	0.057***	0.069***	0.071***	0.046***	0.054***	0.057***	0.034***	0.042***	0.045***
	(2.10)	(1.81)	(1.29)	(5.06)	(5.61)	(6.35)	(5.84)	(6.19)	(6.40)	(5.03)	(4.24)	(4.31)
Div. Op. Dum.	0.003	-0.003	-0.005									
	(0.37)	(-0.22)	(-0.49)									
Block. Own. (> 5%)				-0.001	-0.012	-0.009						
				(-0.05)	(-0.70)	(-0.56)						
Dum.Short-term inv.							0.020***	0.021***	0.021***	0.010***	0.011**	0.011**
							(11.73)	(7.04)	(7.69)	(3.36)	(2.08)	(2.17)
Inst.Own.×Dum.Short-term inv.										0.022***	0.024***	0.021**
										(3.89)	(2.64)	(2.30)
Firm size	-0.018***	-0.017***	-0.021***	-0.013***	-0.014***	-0.016***	-0.013***	-0.013***	-0.015***	-0.012***	-0.013***	-0.015***
	(-14.14)	(-9.59)	(-10.04)	(-8.01)	(-7.52)	(-10.25)	(-8.54)	(-7.86)	(-10.53)	(-8.40)	(-7.62)	(-10.26)
Leverage	-0.302***	-0.303***	-0.280***	-0.354***	-0.351***	-0.348***	-0.355***	-0.352***	-0.349***	-0.356***	-0.353***	-0.349***
	(-22.87)	(-15.81)	(-16.05)	(-20.60)	(-20.26)	(-26.45)	(-21.97)	(-21.01)	(-26.98)	(-22.10)	(-21.07)	(-27.01)
MTB	0.031***	0.028***	0.027***	0.022***	0.020***	0.019***	0.022***	0.020***	0.018***	0.022***	0.020***	0.018***
	(15.60)	(10.69)	(11.49)	(11.34)	(9.33)	(11.44)	(10.69)	(9.24)	(11.27)	(10.64)	(9.16)	(11.29)
Ind. Cash flow risk	0.248***	0.324***	-0.126	0.352***	0.393***	0.084	0.348***	0.393***	0.075	0.346***	0.394***	0.075
	(7.79)	(5.17)	(-1.20)	(12.60)	(6.67)	(1.07)	(12.84)	(6.77)	(0.97)	(13.05)	(6.80)	(0.96)
Net equity issuance	0.196***	0.143***	0.141***	0.164***	0.166***	0.160***	0.159***	0.161***	0.155***	0.159***	0.161***	0.155***
	(4.06)	(3.94)	(5.26)	(8.11)	(8.75)	(10.54)	(7.84)	(8.43)	(10.34)	(7.88)	(8.47)	(10.36)
Net debt issuance	0.302***	0.203***	0.199***	0.302***	0.261***	0.255***	0.299***	0.259***	0.253***	0.300***	0.260***	0.253***
	(8.84)	(3.13)	(2.88)	(10.23)	(6.48)	(6.92)	(10.20)	(6.52)	(6.98)	(10.22)	(6.53)	(6.98)
R&D	0.562***	0.568***	0.404***	0.529***	0.548***	0.420***	0.525***	0.542***	0.413***	0.526***	0.543***	0.414***
	(9.74)	(10.66)	(7.37)	(12.46)	(13.74)	(11.01)	(12.42)	(13.69)	(10.88)	(12.44)	(13.73)	(10.92)
Cash flow	-0.107***	-0.121***	-0.116***	-0.028	-0.036	-0.034**	-0.030	-0.039	-0.036**	-0.031	-0.040*	-0.037**
	(-4.49)	(-3.64)	(-4.08)	(-1.51)	(-1.52)	(-2.16)	(-1.59)	(-1.63)	(-2.34)	(-1.62)	(-1.66)	(-2.39)
Net working capital	-0.280***	-0.297***	-0.328***	-0.309***	-0.316***	-0.349***	-0.308***	-0.316***	-0.348***	-0.308***	-0.316***	-0.348***
	(-17.32)	(-18.20)	(-16.82)	(-28.35)	(-22.65)	(-22.71)	(-28.60)	(-22.68)	(-22.69)	(-28.78)	(-22.72)	(-22.74)
Capital expenditure	-0.659***	-0.642***	-0.516***	-0.701***	-0.690***	-0.620***	-0.713***	-0.705***	-0.632***	-0.714***	-0.706***	-0.632***
	(-13.22)	(-14.61)	(-11.19)	(-18.95)	(-18.06)	(-18.89)	(-19.40)	(-18.65)	(-19.32)	(-19.36)	(-18.65)	(-19.31)

Continued on next page

Table 6 – continued from previous page

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Acquisition	-0.501***	-0.448***	-0.428***	-0.524***	-0.504***	-0.483***	-0.529***	-0.511***	-0.489***	-0.530***	-0.511***	-0.490***
	(-16.64)	(-8.31)	(-8.89)	(-16.82)	(-14.40)	(-17.66)	(-16.91)	(-14.62)	(-18.14)	(-16.77)	(-14.49)	(-18.14)
Dividend dummy	-0.035***	-0.039***	-0.028***	-0.029***	-0.030***	-0.023***	-0.024***	-0.024***	-0.018***	-0.023***	-0.024***	-0.018***
	(-6.13)	(-7.23)	(-5.20)	(-7.74)	(-5.82)	(-5.38)	(-6.43)	(-4.84)	(-4.29)	(-6.40)	(-4.74)	(-4.16)
IPO2	0.004	0.012	0.017**	0.028***	0.030***	0.033***	0.022***	0.023***	0.027***	0.022***	0.024***	0.028***
	(0.73)	(1.58)	(2.05)	(4.83)	(3.95)	(6.98)	(3.56)	(3.00)	(5.72)	(3.60)	(3.14)	(5.93)
IPO3	0.007	0.012	0.016**	0.010*	0.011*	0.015***	0.006	0.007	0.011**	0.006	0.008	0.012***
	(0.85)	(1.22)	(2.25)	(1.74)	(1.75)	(3.33)	(1.11)	(1.09)	(2.51)	(1.11)	(1.14)	(2.59)
IPO4	0.003	0.000	0.008	0.007**	0.006	0.010**	0.004	0.003	0.007	0.004	0.003	0.007*
	(0.68)	(0.06)	(1.17)	(2.83)	(1.16)	(2.30)	(1.69)	(0.52)	(1.62)	(1.57)	(0.54)	(1.66)
IPO5	0.002	0.000	0.006	0.002	0.003	0.006	0.000	0.001	0.004	0.000	0.001	0.004
	(0.36)	(-0.02)	(0.81)	(0.60)	(1.06)	(1.33)	(0.08)	(0.28)	(0.88)	(0.09)	(0.31)	(0.91)
Intercept	0.293***	0.296***	0.345***	0.280***	0.280***	0.321***	0.272***	0.271***	0.312***	0.276***	0.275***	0.315***
	(20.12)	(15.32)	(16.90)	(48.14)	(24.43)	(23.92)	(40.59)	(23.66)	(23.15)	(46.86)	(23.96)	(23.02)
R^2_{adj}	0.62	0.59	0.6	0.54	0.54	0.55	0.54	0.54	0.56	0.54	0.54	0.56

Table 7
Alternative inforamtion channals: stock liquidity, analyst coverage v.s. short selling

This table presents the results for the survival test of different information channels. The main purpose is to investigate if short selling has unique effect on cash holding compared to alternative information channels. The specification is $Cash\ ratio_{i,t} = Intercept + Short\text{-}insterest\ ratio_{i,t-1} + Stock\ liquidity_{i,t-1} + Analyst\ coverage_{i,t-1} + Controls + \epsilon_{i,t}$. Two standard measures of stock liquidity are used: one is Acharya and Pedersen's (2005) adjusted version of Amihud (2002) illiquidity measure and the other is the logarithm of relative effect bid-ask spread (Log_resprd). Analyst coverage is used as proxy for the informational role of financial analysts. Columns (2) to (7) demonstrate the results for the original liquidity measures and analyst coverage. To address the collinearity concern for liquidity measures and analyst coverage with firm size, in each year the corresponding variables are regressed on Firm size and the residuals are used in further tests. The corresponding results are demonstrated in Columns (8) to (13). For each specification, three different estimators are shown: Fama-MacBeth (1973) estimator (FM), OLS estimator clustering on both firm and year dimensions (Cluster2), and industry and year fixed effect estimator (FE). The t-values in Fama-MacBeth estimators are calculated based on Newey and West (1987) standard errors. The t-values in firm and year clustered estimator is based on the two-dimensional standard error proposed in Petersen (2009). The t-values in industry and year fixed-effect estimators are adjusted for heteroskedasticity by firm cluster. Fama-French 48-industry categories are used for industry classification. All t-values are in parentheses under corresponding coefficients. Statistical significance at the 1%, 5% and 10% level are indicated by ***, **, and * respectively.

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Short-interest ratio	0.295***	0.301***	0.273***	0.344***	0.279***	0.291***	0.284***	0.299***	0.261***	0.326***	0.299***	0.264***
	(6.10)	(6.45)	(6.28)	(7.68)	(5.44)	(6.70)	(5.68)	(6.28)	(6.01)	(6.90)	(5.81)	(6.10)
Illiq.	-0.002***	-0.002***	-0.002***									
	(-11.48)	(-7.86)	(-9.32)									
Log_resprd				-0.017***	-0.015***	-0.017***						
				(-3.57)	(-5.22)	(-6.46)						
Analyst cov.	0.006**	0.008***	0.010***	0.006***	0.010***	0.010***						
	(2.24)	(3.12)	(4.48)	(3.26)	(3.98)	(4.58)						
Illiq, res.							-0.002***	-0.002***	-0.002***			
							(-11.84)	(-8.56)	(-9.61)			
Log_resprd, res.										-0.021***	-0.023***	-0.022***
										(-4.23)	(-5.34)	(-8.44)
Analyst cov., res.							0.006***	0.009***	0.010***	0.006***	0.008***	0.009***
							(2.87)	(3.55)	(4.57)	(4.48)	(3.28)	(4.02)
Firm size	-0.019***	-0.019***	-0.022***	-0.021***	-0.020***	-0.023***	-0.011***	-0.011***	-0.013***	-0.012***	-0.012***	-0.014***
	(-12.98)	(-11.14)	(-14.11)	(-6.85)	(-9.02)	(-12.67)	(-11.48)	(-7.86)	(-10.29)	(-10.50)	(-8.37)	(-10.83)
Leverage	-0.345***	-0.342***	-0.339***	-0.335***	-0.335***	-0.333***	-0.344***	-0.341***	-0.337***	-0.332***	-0.331***	-0.328***
	(-18.82)	(-19.51)	(-26.12)	(-17.63)	(-18.52)	(-25.20)	(-18.81)	(-19.80)	(-25.98)	(-17.51)	(-18.74)	(-24.81)
MTB	0.019***	0.017***	0.015***	0.019***	0.018***	0.016***	0.019***	0.017***	0.015***	0.018***	0.016***	0.015***
	(10.72)	(8.55)	(9.51)	(10.72)	(8.16)	(9.38)	(10.48)	(8.35)	(9.32)	(10.69)	(7.73)	(8.89)
Net work capital	-0.306***	-0.314***	-0.345***	-0.305***	-0.308***	-0.345***	-0.306***	-0.314***	-0.345***	-0.305***	-0.313***	-0.344***
	(-25.58)	(-21.67)	(-22.77)	(-24.24)	(-20.97)	(-22.82)	(-25.60)	(-21.82)	(-22.80)	(-24.25)	(-21.51)	(-22.88)
Net equity issuance	0.156***	0.157***	0.150***	0.167***	0.172***	0.162***	0.147***	0.147***	0.140***	0.159***	0.160***	0.153***
	(7.89)	(8.59)	(10.06)	(8.00)	(9.02)	(10.36)	(7.32)	(7.87)	(9.40)	(7.22)	(8.42)	(9.96)
Net debt issuance	0.299***	0.257***	0.251***	0.289***	0.253***	0.247***	0.290***	0.249***	0.241***	0.279***	0.240***	0.234***
	(10.02)	(6.37)	(7.01)	(9.39)	(5.92)	(6.61)	(9.81)	(6.24)	(6.86)	(8.92)	(5.63)	(6.42)
Dividend dummy	-0.026***	-0.026***	-0.020***	-0.027***	-0.028***	-0.022***	-0.025***	-0.026***	-0.020***	-0.027***	-0.029***	-0.023***
	(-8.60)	(-5.47)	(-4.65)	(-7.35)	(-5.51)	(-5.14)	(-8.43)	(-5.41)	(-4.59)	(-7.33)	(-5.88)	(-5.32)
R&D	0.513***	0.528***	0.400***	0.524***	0.542***	0.415***	0.514***	0.528***	0.402***	0.524***	0.536***	0.416***
	(12.98)	(13.50)	(10.55)	(13.53)	(13.90)	(10.66)	(12.74)	(13.54)	(10.60)	(13.48)	(13.98)	(10.73)
Capital expenditure	-0.728***	-0.723***	-0.646***	-0.727***	-0.709***	-0.643***	-0.728***	-0.720***	-0.645***	-0.728***	-0.720***	-0.645***
	(-17.40)	(-17.52)	(-19.82)	(-15.27)	(-16.45)	(-19.53)	(-17.72)	(-17.90)	(-19.87)	(-15.56)	(-17.03)	(-19.72)
Acquisition	-0.528***	-0.502***	-0.481***	-0.524***	-0.496***	-0.475***	-0.536***	-0.507***	-0.489***	-0.535***	-0.509***	-0.489***
	(-16.60)	(-13.62)	(-18.09)	(-14.14)	(-12.75)	(-17.21)	(-16.89)	(-13.85)	(-18.72)	(-14.28)	(-13.01)	(-18.05)

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Table 7 – continued from previous page

Cash ratio	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE	FM	Cluster2	FE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Cash flow	-0.015	-0.024	-0.023	-0.022	-0.025	-0.024	-0.021	-0.032	-0.031**	-0.029	-0.035	-0.032**
	(-0.73)	(-1.07)	(-1.48)	(-1.14)	(-1.04)	(-1.54)	(-1.03)	(-1.39)	(-2.01)	(-1.38)	(-1.41)	(-2.07)
Ind. cash flow risk	0.337***	0.389***	0.053	0.326***	0.360***	0.029	0.336***	0.391***	0.056	0.321***	0.378***	0.026
	(12.47)	(6.82)	(0.68)	(12.29)	(5.99)	(0.36)	(12.35)	(6.99)	(0.72)	(12.17)	(6.53)	(0.32)
IPO2	0.023***	0.023***	0.027***	0.031***	0.030***	0.033***	0.023***	0.023***	0.027***	0.031***	0.029***	0.033***
	(4.19)	(3.35)	(5.85)	(5.28)	(4.00)	(6.71)	(4.07)	(3.27)	(5.70)	(5.21)	(3.83)	(6.76)
IPO3	0.007	0.008	0.012***	0.011*	0.012*	0.015***	0.007	0.007	0.011**	0.011*	0.011*	0.015***
	(1.35)	(1.33)	(2.65)	(1.90)	(1.94)	(3.26)	(1.31)	(1.23)	(2.56)	(1.89)	(1.73)	(3.39)
IPO4	0.003	0.003	0.006	0.005	0.005	0.008*	0.003	0.002	0.006	0.005	0.004	0.009*
	(1.04)	(0.52)	(1.47)	(1.45)	(1.06)	(1.79)	(1.01)	(0.39)	(1.37)	(1.48)	(0.82)	(1.94)
IPO5	-0.001	0.000	0.002	0.002	0.004	0.006	-0.001	-0.001	0.002	0.002	0.003	0.006
	(-0.31)	(-0.05)	(0.47)	(0.59)	(1.35)	(1.33)	(-0.32)	(-0.29)	(0.40)	(0.59)	(0.92)	(1.45)
Intercept	0.338***	0.335***	0.377***	0.237***	0.246***	0.279***	0.294***	0.291***	0.329***	0.296***	0.294***	0.325***
	(44.48)	(25.10)	(25.84)	(14.84)	(18.95)	(21.01)	(51.25)	(26.25)	(25.20)	(50.01)	(25.92)	(25.22)
R^2_{adj}	0.55	0.54	0.56	0.55	0.54	0.56	0.55	0.54	0.56	0.55	0.54	0.56

Table 8
Simultaneous equation system: cash holdings vs. short sales

The system includes two equations with endogenous dependent variables as Cash ratio and Short-interest ratio: $Cash\ ratio_t = \alpha_0 + \boldsymbol{\alpha_1} Short\text{-}interest\ ratio_t + \sum_{j=2} \alpha_j X_{j,t-1} + \eta_t$, $Short\text{-}interest\ ratio_t = \beta_0 + \boldsymbol{\beta_1} Cash\ ratio_t + \sum_{k=2} \beta_k Z_{k,t-1} + \xi_t$. Endogenous variables take the values in current year, while exogenous variables (except IPO2 to IPO5) take the values in the previous year. The coefficients are estimated following the two-step procedure of Chordia, Huh, and Subrahmanyam (2007). In the first step, *2SLS* estimator is calculated in each year. In the second step, the coefficients of the *2SLS* estimator are averaged across time series dimension. *Panel A* demonstrates the results of the equation with Cash ratio as dependent variable. *Panel B* demonstrates the results of the equation with Short-interest ratio as dependent variable. Fama-French 48-industry dummies are controlled but the relevant coefficients are not reported here. The t-statistics are based on Newey and West (1987) standard errors. Statistical significance at the 1%, 5% and 10% level are indicated by ***, **, and * respectively.

	Coefficient	t-statistics
Panel A: Cash ratio		
Short-interest ratio	1.656***	6.24
Firm size	-0.018***	-12.18
Leverage	-0.264***	-19.80
MTB	0.015***	6.05
Net working capital	-0.277***	-20.94
Net equity issuance	0.047	1.19
Net debt issuance	0.202***	11.15
Dividend dummy	-0.015***	-3.15
R&D	0.516***	10.94
Capital expenditure	-0.633***	-14.98
Acquisition	-0.426***	-16.50
Cash flow	-0.075**	-2.17
Operating income volatility	0.669***	5.93
IPO2	0.002	1.13
IPO3	0.001	0.07
IPO4	0.012**	2.78
IPO5	0.000	-0.07
Intercept	0.229***	23.07
Panel B: Short-interest ratio		
Cash ratio	0.005	0.93
Institutional ownership	0.048***	3.75
Illiq	-0.001***	-4.67
Divergence of opinion	0.002***	3.32
Equity beta	0.007***	5.63
Idiosyncratic risk	0.072***	8.05
Firm age	-0.002***	-4.24
Return volatility	0.404***	3.06
Stock return	0.000	-0.55
Leverage	0.013***	8.34
MTB	0.003***	6.06
Cash flow	-0.011***	-4.39
Analyst coverage	0.001	0.99
Intercept	-0.018***	-3.72

Financial market, stakeholder relationship, and corporate policies *

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Abstract

This paper proposes a theoretical model to illustrate a mechanism by which financial markets affect corporate investment and cash policies when managers do not learn from financial markets. Informed trading in financial markets facilitates the incorporation of private information into security prices. Corporate stakeholders learn from the security prices and decide to update their relationships with the firms. Stakeholders' decisions may generate new investment opportunities, which require immediate liquidity support. Precautionary motives drive the firms to hoard liquidity in advance. The model demonstrates that corporate cash holdings can stimulate new investment opportunities by affecting the stakeholder's expected utility. The optimal cash holding is a trade-off between the cost of external financing and the firm's expected payoff of the new investment. Market liquidity of securities is linked to investment and cash policies through firms' fundamental characteristics. Firms' relationships with stakeholders and the precision of managers' private information both affect firm value.

Keywords: Informed trading, stakeholder, investment, cash holding, market liquidity.
JEL: G14, G32.

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1 Introduction

Financial markets have feedback effects on the real economy because of the informational role of security prices (Bond, Edmans, and Goldstein, 2012). This concept dates back to Hayek (1945), who proposes that society can share information through the price system. Decision makers base their actions on the information that is learned from prices (Baumol, 1965; Bond, Goldstein and Prescott, 2010; Goldstein, Ozdenoren, and Yuan, 2013). Corporate managers are influenced by the prices in financial markets when making corporate policies (Dow and Gorton, 1997; Subruhmanyam and Titman, 1999; Luo, 2005; Chen, Goldstein and Jiang, 2007; Bakke and Whited, 2010; Fresard, 2012; Edmans, Goldstein, and Jiang, 2012; Hau and Lai, 2013). One prevalent mechanism through which financial markets have real effects on corporate policies relies on the idea that managers learn from prices in financial markets[1], which is reasonable and intuitive. However, given the fact that managers naturally have an informational advantage with regard to the firms they operate, will financial markets affect corporate policies if managers do not need to learn from financial markets? This paper proposes a theoretical model to address this concern and suggests a channel based on the interaction between managers and other stakeholders.

Corporate stakeholders such as customers, suppliers, and capital providers can learn from financial markets when making decisions. Because these decisions can affect firm value, managers should take them into account when making corporate policies (Jensen, 2001; Titman, 1984; Cornell and Shapiro, 1987; Subruhmanyam and Titman, 2001; Fee, Hadlock and Thomas, 2006; Kale and Shahrur, 2007; Banerjee, Dasgupta, and Kim, 2008; Almanzan, Suarez and Titman, 2009; Bushee and Miller, 2012). The learning of stakeholders (other than managers) and the intersection between these stakeholders and managers constitute a channel that links financial markets and corporate policies.

The model in this paper includes the following three components: a financial market, a stakeholder, and a firm manager. The financial market follows the setting of Kyle (1985). A informed investor, who possesses private information concerning the firm's future cash

[1] An alternative mechanism relies on the idea that managers are affected by compensation contracts that are contingent on market prices. In this paper, the agency problem is not considered; therefore, this mechanism is not the focus of this paper.

flow, trades the security in the financial market. The private information is incorporated into the security price through informed trading. The stakeholder learns from the security price and makes a decision regarding whether to strengthen the relationship with the firm.[2] A new investment opportunity appears when the stakeholder strengthens the relationship with the firm.

A new investment opportunity requires immediate liquidity support (Huberman, 1984). The manager makes the investment and cash policies simultaneously to maximize firm value. The manager has private information regarding future cash flow even earlier than the informed trader, and therefore, does not need to learn from the financial market. Expecting the possible future investment opportunity, the manager hoards liquidity in advance for precautionary motives (Keynes, 1936; Opler, Pinkowitz, Stulz and Williamson, 1999; Almeida, Campello, and Weisbach, 2004; Acharya, Almeida, and Campello, 2007; Han and Qiu, 2007; Bates, Kahle, and Stulz, 2009). Meanwhile, there are costs for cash holdings.[3] The optimal cash holding is a trade-off between the cost of cash holding and the expected benefit from the new investment opportunity.

This paper demonstrates an endogenous linkage between security market liquidity and corporate policies. The literature on market microstructure suggests that the market liquidity associates with information asymmetry (Bagehot, 1971; Copeland and Galai, 1983; Glosten and Milgrom, 1985; Kyle, 1985; Easley and O'Hara, 1987) and has an impact on the cost of capital (Amihud and Mendelson, 1986; Diamond and Verrecchia 1991), and subsequently on corporate financial polices (Amihud and Mendelson, 1991). Lipson and Mortal (2009) find empirical evidence that firms with more liquid equity have lower leverage. It is not an easy task to clearly understand the relationship between stock liquidity and corporate policies because both concepts are endogenous. The model in this paper sheds light on this issue by demonstrating that security market liquidity and

[2]For example, customers may infer that a higher stock price is a signal of good product quality and thereby decide to buy more products; Suppliers may infer that a higher stock price is a signal of a brighter future and thereby may increase trade credits or specific investments related to the firm's business.

[3]Literature regarding cash holdings suggests costs for cash holdings. For example, Opler, Pinkowitz, Stulz and Williamson (1999) argue that the cost of holding liquid assets includes a lower rate of return on these assets and tax disadvantages. Riddick and Whited (2009) argue that firms face a dynamic trade-off between the tax penalty and the reduction in expected future financing costs.

corporate policies are linked through the fundamental characteristics of the firm.

This paper relates closely to three existing theoretical papers. The first is Subruhmanyam and Titman (2001), who demonstrate the feedback effect of stock prices on corporate cash flows when managers do not need to learn from financial markets. If the stock prices can affect cash flows, it is intuitive that financial markets can influence corporate policies. This paper extends the work of Subruhmanyam and Titman (2001) by studying the link between financial markets and corporate policies and by including the manager as one party in the model. Whereas Subruhmanyam and Titman (2001) do not consider the possibility of financial constraints, in this paper the manager hoards cash to avoid future financial constraints. The second related paper is Bond, Goldstein, and Prescott (2010), who study the market-based corrective actions of economic agents. Bond et al. focus on the interaction between prices in the financial market and the actions of the economic agent, assuming that the agent must learn from the financial market for her decision-making. The model in this paper includes the financial market and two economic agents (the firm manager and the stakeholder). Only one economic agent (the stakeholder) learns from the financial market and the interaction between these two economic agents plays a key role. The third related paper is Goldstein, Ozdenoren, and Yuan (2013), who study the trading frenzies in financial markets and its feedback effect on corporate capital providers. Goldstein et al. focus on the mechanism of trading frenzies in financial markets and the feedback effects on capital providers, whereas this paper focuses on the feedback effects on corporate policies.

This paper contributes to the literature on the real effect of financial markets by illustrating a channel through which the financial market affects corporate policies even when the manager does not learn from the financial market. The model facilitates a better understanding of the informational role of prices in financial markets. This paper also contributes to the literature on market liquidity of financial securities by demonstrating that market liquidity links with cash and investment policies through the fundamental characteristics of the firm. Finally, this paper shows a mechanism by which the relationship with stakeholders and the precision of managers' private information affect firm value.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 provides an analysis of equilibrium. Section 4 discusses the model implications and Section 5 concludes.

2 The Model

The model includes a firm manager, a stakeholder, and a financial market that trades a security of the firm. There are three key dates, $t = 0, 1, 2$. At $t = 0$, the firm has the asset in place, which generates cash flow only at $t = 2$. At $t = 0$, the firm manager knows the payoff of the asset in place, whereas others are uncertain about the payoff. However, the manager can not share the private information with others in a credible way. In this model, the agency problem is not considered, and therefore the firm and the manager will be used interchangeably. At $t = 0$, the manager makes the investment policy and the cash policy.

At $t = 1$, the informed trader appears in the financial market and the private information is incorporated into the security price. Following Subruhmanyam and Titman (2001), the stakeholder can learn from the security price. However, instead of many stakeholders, this paper has only one representative stakeholder (think of a marginal stakeholder in Subruhmanyam and Titman (2001)). Based on the information learned from the security price, the stakeholder decides whether to strengthen the relationship with the firm.[4] If so, a new investment opportunity arises. This part of the model can be regarded as a reduced form of Subruhmanyam and Titman (2001). When the opportunity is available at $t = 1$, the firm invests using the cash holdings. At $t = 2$, the uncertainty is realized and all parties are paid. All parties are risk-neutral and the discount factor is set to 1.

2.1 Financial market

Following Subruhmanyam and Titman (2001), only the security of the asset in place is traded in the financial market. The microstructure of the financial market is in line with

[4]For example, customers may strengthen the relationship by buying more products; suppliers may strengthen the relationship by providing more trade credits or invest more in the business related to the firm; capital providers may strengthen the relationship by providing cheaper financing.

Kyle (1985). At $t = 1$, an informed trader and a noise trader submit market orders simultaneously to a competitive market maker. The informed trader owns private information regarding the payoff of the asset in place at $t = 2$, which is knows by the stakeholder as

$$\tilde{v} = \bar{F} + \delta,$$

where $\bar{F}$ is expected value and $\delta \sim N(0, \sigma_0^2)$. The private information owned by the informed trader is denoted as $\hat{\delta}$, which is the realization of δ at $t = 2$. The informed trader uses a linear trading strategy

$$\tilde{x}(\hat{\delta}) = \alpha + \beta \cdot \hat{\delta},$$

where $\tilde{x}$ is the trading volume, α and β are coefficients. The trading volume of the noise trader, $\tilde{u}$, follows a normal distribution

$$\tilde{u} \sim N(0, \sigma_u^2).$$

The market maker, who only observes the aggregate order flow $\tilde{x} + \tilde{u}$, sets a price P to clear the market:

$$P(\tilde{x} + \tilde{u}) = E[\tilde{v}|\tilde{x} + \tilde{u}] = \mu + \lambda(\tilde{x} + \tilde{u}).$$

The objective of the informed trader is to maximize her expected payoff at $t = 2$:

$$E[(\bar{F} + \hat{\delta}) - P(\tilde{x} + \tilde{u})] \cdot \tilde{x}.$$

2.2 The stakeholder

At $t = 1$, the stakeholder observes the price P after the informed trading and decides whether to strengthen the relationship with the firm. The stakeholder's utility function is as follows:

$$\rho_1(\bar{F} + \delta) + \rho_2 G(I),$$

where ρ_1 and ρ_2 are the weights for payoffs from the asset in place and the new investment, respectively, $G(\cdot)$ is the payoff function for the new investment, which is knows by the stakeholder and satisfies the standard properties such as $G'(I) > 0$, $G''(I) < 0$, $G(0) = 0$, and $G'(0) = +\infty$, and I is the firm's investment. However, the stakeholder must make

the decision before the firm invests, meaning that I should be understood as the expected firm investment. The rational stakeholder understands that the firm will not invest more than the first best investment level $I_0^* = (G')^{-1}(1)$ and can not invest more than its cash holding C, which is assumed to be observable at $t = 1$, i.e., $I \leqslant \min\{I_0^*, C\}$. However, the stakeholder does not know the cost of cash holdings, therefore, can not directly infer $\hat{\delta}$ through C observed.

The stakeholder has a threshold w for her decision-making. The stakeholder strengthens her relationship if and only if

$$E[\rho_1(\bar{F} + \delta) + \rho_2 G(I)|P, C] \geqslant w. \tag{1}$$

The threshold w can be understood as a proxy for the original relationship between the stakeholder and the firm. The stronger the original relationship is, the lower the threshold w is.

2.3 The firm manager

At $t = 0$, the manager makes corporate policies to maximize the expected firm value. At $t = 0$, the manager is the only one who owns the private information ($\hat{\delta}$) regarding the value of the asset in place; however, the manager cannot credibly transfer this information to others and is not allowed to trade in the financial market. The manager expects that at $t = 1$ certain outsider will learn the private information and begin the informed trading. At that time, a new investment opportunity may appear depending on the stakeholder's reaction to the security price. Precautionary motives drive the firm to save cash at $t = 0$ because cash needs to be in place before the investment opportunity arises, as in Huberman (1984).

Assume there is no cash holding at the beginning of $t = 0$. To hoard liquidity, the firm must raise external financing at $t = 0$ and save until $t = 1$ to support the new investment. A negative payout at $t = 0$ indicates this external financing, whereas the payout at $t = 1$ or $t = 2$ must be non-negative. In this model, the cost of cash holding is represented as extra external financing; in other words, if the manage expects to invest C at $t = 1$, she has to raise $(1 + \kappa) \cdot C$ at $t = 0$. Here $\kappa > 0$ is a measure for the cost of cash holding.

After the investment at $t = 1$, the firm is supposed to pay out the remaining cash because there is no longer a need for cash holding.

The manager's objective function is as follows:

$$\max\{d_0 + d_1 + d_2\}, s.t.$$

$$\begin{aligned} d_0 &= -(1+\kappa)\cdot C < 0 \\ d_1 &= p\cdot(C-I) + (1-p)\cdot C \\ d_2 &= (\bar{F} + \hat{\delta}) + p\cdot G(I) \end{aligned}$$

where d_i is the payout at $t = i$, i=0, 1, 2, p is the ex ante probability of the new investment opportunity depending on the stakeholder's action, C is the cash holding at $t = 1$, and κ is the cost of cash holding.

3 Equilibrium analysis

The equilibrium is defined as $\{x, P; a_s; C, I\}$, where x is the volume of informed trading, P is the security price at $t = 1$, a_s is the strategy[5] of the stakeholder, C is the target cash holding at $t = 1$, and I is the firm's investment strategy[6].

The equilibrium is derived backwards from $t = 1$. According to the setting of the financial market, the traders and the market maker will not be affected by the actions of the stakeholder and the firm manager. Therefore, at $t = 1$, in the financial market $\{x(\hat{\delta}), P(x, \tilde{u})\}$ is derived as follows

$$\tilde{x}(\hat{\delta}) = \beta\hat{\delta} \tag{2}$$

$$P(\tilde{x} + \tilde{u}) = \bar{F} + \lambda(\tilde{x} + \tilde{u}), \tag{3}$$

where $\beta = \sigma_u/\sigma_0$, $\lambda = \dfrac{\sigma_0}{2\cdot\sigma_u}$. The quantity $\dfrac{1}{\lambda} = \dfrac{2\cdot\sigma_u}{\sigma_0}$ can be regarded as a market liquidity measure for the security. Therefore, given σ_0, the more volatile the noise trading is, the more liquid the security is. The noise trader facilitates the informed investor to

[5]The action set of the stakeholder includes "to strengthen" and "not to strengthen" the relationship with the firm.

[6]The investment strategy I is made at $t = 0$, which states how the firm should invest according to the stakeholder's action at $t = 1$.

disguise informed trading in front of the market maker.

The stakeholder observes the security price P and infers the information about δ for her decision-making. To the stakeholder, the condition (1) is equivalent to

$$\rho_1(\bar{F} + E[\delta|P]) + \rho_2 E[G(I)|C] \geqslant w, \tag{4}$$

where

$$\begin{aligned} E[\delta|P] &= E[\delta|P = \bar{F} + \lambda(\tilde{x} + \tilde{u})] \\ &= E[\delta|P = \bar{F} + \lambda(\beta \cdot \delta + \tilde{u})] \\ &= E[\delta|\delta + 2\lambda\tilde{u} = 2(P - \bar{F})] \\ &= P - \bar{F}. \end{aligned}$$

Therefore, the stakeholder will strengthen her relationship with the firm if and only if

$$\rho_1 P + \rho_2 E[G(I)|C] \geqslant w, \tag{5}$$

where $I \leqslant \min\{I_0^*, C\}$.

At $t = 1$, if Condition (5) is satisfied, a new investment opportunity will appear and the manager can invest using cash holdings. As expected by the stakeholder, the new investment will be less than the first best level I_0^*. The remaining cash holdings, if any, will be paid out. If Condition (5) is not satisfied, no investment opportunity will appear and the manager will pay out all of the cash holdings.

At $t = 0$, the manager makes the decision of cash holding C. The manager knows that the stakeholder expects that the firm will not invest more than I_0^*, therefore, the cash holdings in excess of I_0^* will neither affect stakeholder's decision, nor be invested at $t = 1$. The optimal cash holdings must satisfy $C \leqslant I_0^*$, which means $I \leqslant C \leqslant I_0^*$. Furthermore, given the cost of cash holdings, any cash holdings in excess of the new investment can not be optimal. Therefore, the optimal cash holdings must satisfy $C = I \leqslant I_0^*$. To the stakeholder, $E[G(I)|C] = G(C)$.

At $t = 0$, the manager owns the private information $\hat{\delta}$. However, the security price P

at $t = 1$ is uncertain to her because of the existence of noise trader:

$$\begin{aligned} P|_{\delta=\hat{\delta}} &= \bar{F} + \lambda(\tilde{x} + \tilde{u}) \\ &= \bar{F} + \lambda(\beta\hat{\delta} + \tilde{u}) \\ &= \bar{F} + \frac{\hat{\delta}}{2} + \lambda\tilde{u},\ \tilde{u} \sim N(0, \sigma_u^2), \end{aligned}$$

i.e.,

$$P|_{\delta=\hat{\delta}} \sim N\left(\bar{F} + \frac{\hat{\delta}}{2}, \frac{\sigma_0^2}{4}\right). \tag{6}$$

At $t = 0$, from the manager's viewpoint, the ex ante probability for the stakeholder to strengthen the relationship, i.e., the probability a new investment opportunity will appear at $t = 1$, is given as

$$\begin{aligned} p(C) &= Prob\{\rho_1 P + \rho_2 G(C) \geqslant w\} \\ &= Prob\left\{P \geqslant \frac{w - \rho_2 G(C)}{\rho_1}\right\} \\ &= Prob\left\{\frac{P - (\bar{F} + \hat{\delta}/2)}{\sigma_0/2} \geqslant \frac{2[w - \rho_2 G(C) - \rho_1(\bar{F} + \hat{\delta}/2)]}{\rho_1\sigma_0}\right\}, \end{aligned}$$

i.e.

$$p(C) = \Phi\left[\frac{2}{\sigma_0}\frac{\rho_2}{\rho_1}G(C) + \frac{2[\rho_1(\bar{F} + \hat{\delta}/2) - w]}{\rho_1\sigma_0}\right], \tag{7}$$

where $\Phi[\cdot]$ is the probability distribution function of standard normal distribution, $C = I \leqslant I_0^*$ is cash holdings at $t = 1$, I is the investment at $t = 1$ given the opportunity is available.

The objective function of the manager can be written as

$$\max_{0\leqslant I=C\leqslant I_0^*}\{d_0 + d_1 + d_2\}, s.t.$$

$$\begin{aligned} d_0 &= -(1+\kappa)C \leqslant 0 \\ d_1 &= p(C)(C - I) + (1 - p(C))C \\ d_2 &= (\bar{F} + \hat{\delta}) + p(C) \cdot G(I) \end{aligned}$$

which is equivalent to

$$\max_{0\leqslant I=C\leqslant I_0^*}\{(\bar{F} + \hat{\delta}) + p(I) \cdot [G(I) - I] - \kappa I\}. \tag{8}$$

The function in (8) is continuous. There must exist an $I^* \in [0, I_0^*]$ that solves the optimization in (8). Given $G'(0) = +\infty$ and $\kappa > 0$, this I^* must be strictly positive and less than the first best investment I_0^*, i.e., $I^* \in (0, I_0^*)$. Therefore, at $t = 0$ the firm must raise external financing $(1+\kappa) \cdot I^*$, which guarantees the cash holdings at $t = 1$ as I^*. The expected firm value is $\{(\bar{F} + \hat{\delta}) + p(I^*) \cdot [G(I^*) - I^*] - \kappa I^*\}$, where $p(C)$ is given in (7). The objective function (8) indicates that the optimal cash holding is a trade-off between the expected payoff of the investment opportunity and the cost of cash holding. The cost of cash holding (κ) decreases the optimal cash holding and has a negative effect on firm value. The equilibrium of the model is summarized in the following proposition.

Proposition 1 *The equilibrium of the model*

Under the model setting described in Section 2, equilibrium is given as follows:

- *The manager*: at $t = 0$, the firm raises external financing $(1+\kappa) \cdot I^*$, where I^* is the optimal solution to the optimization problem (8). This external financing guarantees the cash holding I^* at $t = 1$. At $t = 1$, if an investment opportunity is available, the firm invests the cash saving I^*, otherwise pays out the cash.

- *The financial market*: at $t = 1$, the informed trading volume is given by Equation (2) and the security price is given by Equation (3).

- *The stakeholder*: at $t = 1$, observing the security price P and the firm's cash holding C, the stakeholder strengthens her relationship with the firm if and only if Condition (5) is satisfied.

4 Implications

This section demonstrates several implications of the model, in which corporate policies and financial markets are linked through the shareholder's reaction to the security price.

4.1 The stakeholder, cash holding, growth opportunity, and firm value

According to Equation (7), corporate cash holdings C can stimulate new investment opportunities by affecting the stakeholder's expected payoff. $p(C)$ is increasing with C if and only if $C < I_0^*$, where I_0^* is the first best investment for $G(I)$.

As shown in Equations (7) and (8), the stakeholder affects firm value through the growth opportunity, i.e., the probability of the new investment. The relationship between the stakeholder and the firm has a positive effect on the probability $p(C)$. The relationship is measured by the threshold w. A low value of w indicates a strong relationship, and consequently, a better chance in the future. This can be described as a reputation effect. If the firm has built a good reputation through previous deals with the stakeholder, the firm will benefit in future developments. For example, in practice, a good relationship with banks enables the firm to obtain bank loans. A small increase in the security price may persuade banks to provide cheaper financing. Accordingly, the lower cost of capital may generate more projects with positive NPVs. A similar argument can be made with regard to customers and the quality of a firm's products. By substituting (7) into (8), the envelope theorem implies that the relationship with the stakeholder has a positive effect on firm value.

The preference of the stakeholder can also affect a firm's growth opportunity. Equation (7) shows that the relative importance of a new investment to the asset in place, ρ_2/ρ_1, increases $p(C)$ and firm value (envelope theorem). In practice, new generation of products are emphasized in commercial advertisements, which not only demonstrate the competitive advantage to its rivals but also affect stakeholder's preferences and stimulate growth opportunities.

These arguments are summarized in the following proposition.

Proposition 2 A moderate cash holding has a positive effect on growth opportunities[7]. Mangers can stimulate future growth opportunities and increase firm value by

[7]In this model, C is assumed to be observable to the stakeholder. However, if this assumption is relaxed, Proposition 2 suggests that managers have the incentive to announce or even exaggerate the cash holdings to the public.

strengthening relationships with stakeholders, or by influencing stakeholders' preferences (ρ_2/ρ_1).

4.2 Security market liquidity vs. corporate policies

The informational role of the security price is crucial in the mechanism of the model. The literature regarding market microstructure suggests that market liquidity is associated with information asymmetry (Bagehot, 1971; Copeland and Galai, 1983; Glosten and Milgrom, 1985; Kyle, 1985; Easley and O'Hara, 1987). Market liquidity can affect the cost of capital (Amihud and Mendelson, 1986; Diamond and Verrecchia, 1991) and subsequently corporate policies (Lipson and Mortal, 2009). This model focuses on the cash and investment policies, and illustrates that security market liquidity, cash policy and investment policy are linked through the business risk σ_0, a fundamental characteristics of the firm.

The equilibrium analysis indicates market liquidity as $\frac{1}{\lambda} = \frac{2 \cdot \sigma_u}{\sigma_0}$, which is affected by the firm's business risk σ_0. Meanwhile, Equation (7) shows that the ex ante probability of the investment opportunity is also affected by σ_0. Through the objective function (8), σ_0 may also affect investment and cash policies. The following proposition demonstrates the linkage between security market liquidity and corporate policies.

Proposition 3 *Investment, cash holding and security market liquidity*

Security market liquidity is positively linked with the optimal investment and cash holding through the firm's business risk σ_0 if and only if the following condition is satisfied:

$$\frac{1}{\sigma_0^2} < \frac{1}{[aG(I^*) - b]^2} + \frac{G'(I^*) - 1}{aG'(I^*)(G(I^*) - I^*)(aG(I^*) - b)}, \tag{9}$$

where I^* is the optimal cash holding and investment in (8), $a = \frac{2\rho_2}{\rho_1}$, and $b = \frac{w - \rho_1(\bar{F} + \hat{\delta}/2)}{\rho_1}$. The detailed proof is in the appendix.

4.3 Precision of the manager's private information and firm value

The model in Section 2 assumes that the manager knows the accurate payoff from the asset in place as $\bar{F} + \hat{\delta}$. In this section, the model is generalized to allow some uncertainty

in the manager's private information. Assume that at $t = 0$ the manager knows

$$\delta_M = \hat{\delta} + \theta,$$

where $\hat{\delta}$ is the realization of δ at $t = 2$, and the noise $\theta \sim N(0, \sigma_\theta^2)$. Then at $t = 0$, the manager predicts the security price ($t = 1$) as

$$\begin{aligned} P|_{\delta=\hat{\delta}+\theta} &= \bar{F} + \lambda(\tilde{x} + \tilde{u}) \\ &= \bar{F} + \lambda[\beta(\hat{\delta} + \theta) + \tilde{u}] \\ &= \bar{F} + \frac{\hat{\delta}}{2} + \frac{\theta}{2} + \lambda\tilde{u},\ \tilde{u} \sim N(0, \sigma_u^2),\ \theta \sim N(0, \sigma_\theta^2), \\ &\sim N\left(\bar{F} + \frac{\hat{\delta}}{2}, \frac{\sigma_0^2 + \sigma_\theta^2}{4}\right). \end{aligned}$$

The ex ante probability of the investment opportunity becomes

$$p_M(I) = \Phi\left[\frac{2}{\sqrt{\sigma_0^2 + \sigma_\theta^2}}\frac{\rho_2}{\rho_1}G(I) + \frac{2[\rho_1(\bar{F} + \hat{\delta}/2) - w]}{\rho_1\sqrt{\sigma_0^2 + \sigma_\theta^2}}\right]. \tag{10}$$

Therefore, the precision of the manager's private information ($1/\sigma_\theta$) affects the ex ante probability of a new investment opportunity. Denote I_M^* as the optimal solution of (8) given (10). Then the sign of the effect depends on the following condition:

$$\rho_1(\bar{F} + \hat{\delta}/2) + \rho_2 G(I_M^*) > w. \tag{11}$$

If (11) is satisfied, the information precision has a positive impact on the ex ante probability of investment opportunity; Otherwise, the impact is negative. Combining (10) and (8), the envelope theorem implies that the precision of the private information has a similar impact on firm value as it does on $p(C)$. This finding indicates that the manager has a stronger motive to improve the precision of her private information given an optimistic expectation regarding the growth opportunity. The effects are summarized in the following proposition.

Proposition 4 The precision of a manager's private information has a positive impact

on the ex ante probability of investment opportunity and firm value if condition (11) is satisfied. Otherwise, the impact is negative.

5 Conclusions

This paper proposes a theoretical model to illustrate a channel that links financial markets and corporate policies when managers do not learn from the financial market. The informational role of the security price and the effect of stakeholder decisions on investment opportunities are crucial in the mechanism. In equilibrium, a manager formulates the cash policy and the investment policy simultaneously. Security market liquidity is linked with corporate policies through the fundamental characteristics of the firm. The relationship with the stakeholder and the precision of the manager's private information can affect firm value.

Future research might focus on enriching the model by considering leverage and bankruptcy, or by allowing the financial market to be affected by corporate policies. In that case, there is a trade-off between the enhanced model and the technical complexity, because there may exist multiple non-linear equilibria. Another direction for future research would be to empirically examine the link between financial markets and corporate policies, e.g., the short sale or security liquidity in financial markets and the corporate cash policy.

Appendix

Proof of Proposition 3

Security market liquidity, $\frac{1}{\lambda} = \frac{2\sigma_u}{\sigma_0}$, is decreasing on firm business risk σ_0.

Denote the objective function of the manager as

$$v(I) = p(I)[G(I) - I] - \kappa I + (\bar{F} + \hat{\delta}).$$

The first order condition is

$$p'(I)[G(I) - I] + p(I)[G'(I) - 1] - \kappa = 0, \tag{12}$$

where $p(I) = \Phi\left[\frac{1}{\sigma_0}(a \cdot G(I) - b)\right]$, $a = \frac{2\rho_2}{\rho_1}$, $b = \frac{w - \rho_1(\bar{F} + \hat{\delta}/2)}{\rho_1}$, and $p'(I) = \frac{a}{\sigma_0}G'(I)\phi\left[\frac{1}{\sigma_0}(aG(I) - b)\right]$, $\phi[\cdot]$ is the density function of standard normal distribution.

Denote $p(I)$ as $p(I(\sigma_0), \sigma_0)$. Take partial derivative with respect to σ_0 in equation (12):

$$\left[\frac{\partial^2 p(I,\sigma_0)}{\partial \sigma_0^2}\frac{\partial I}{\partial \sigma_0} + \frac{\partial p'(I,\sigma_0)}{\sigma_0}\right][G(I) - I] + p'(I,\sigma_0)[G'(I) - 1]\frac{\partial I}{\partial \sigma_0} + [\frac{\partial p'(I,\sigma_0)}{\partial I}\frac{\partial I}{\partial \sigma_0}$$
$$+\frac{\partial p(I,\sigma_0)}{\partial \sigma_0}][G'(I) - 1] + p(I,\sigma_0)G''(I)\frac{\partial I}{\partial \sigma_0} = 0.$$

Therefore,

$$\frac{\partial I^*}{\partial \sigma_0} = -\frac{1}{v''(I^*)}\left[\frac{\partial p'}{\partial \sigma_0}(G(I^*) - I^*) + \frac{\partial p}{\partial \sigma_0}(G'(I^*) - 1)\right]. \tag{13}$$

Substitute

$$\frac{\partial p}{\partial \sigma_0} = \phi\left[\frac{aG(I^*) - b}{\sigma_0}\right]\left[-\frac{aG(I^*) - b}{\sigma_0^2}\right],$$

and

$$\begin{aligned}\frac{\partial p'}{\partial \sigma_0} &= -\frac{a}{\sigma_0^2}G'(I^*)\phi\left[\frac{aG(I^*) - b}{\sigma_0}\right] - \frac{a}{\sigma_0}G'(I^*)\frac{aG(I^*) - b}{\sigma_0}\phi\left[\frac{aG(I^*) - b}{\sigma_0}\right]\left[-\frac{aG(I^*) - b}{\sigma_0^2}\right] \\ &= \phi\left[\frac{aG(I^*) - b}{\sigma_0}\right]G'(I^*)\frac{a}{\sigma_0^2}\left[\frac{(aG(I^*) - b)^2}{\sigma_0^2} - 1\right],\end{aligned}$$

into (13), and notice $G(I^*) - I^* > 0$ and $G'(I^*) - 1 > 0$ since $I^* \leqslant I_0^*$, and notice $v''(I^*) < 0$,

a sufficient and necessary condition for a negative $\frac{\partial I^*}{\partial \sigma_0}$ is

$$\frac{1}{\sigma_0^2} < \frac{1}{[aG(I^*) - b]^2} + \frac{G'(I^*) - 1}{aG'(I^*)(G(I^*) - I^*)(aG(I^*) - b)}. \tag{14}$$

It means security market liquidity is positively linked with optimal investment and cash holding through the firm's business risk if and only if condition (14) is satisfied. Done. □

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Education

3/2010 – 7/2013	PhD candidate, Swiss Finance Institute Department of Banking and Finance, University of Zurich Major field of study: Finance Supervisor: Prof. Dr. Kjell G. Nyborg
8/2007 – 2/2010	Research scholar, PhD candidate Department of Finance, Norwegian School of Economics Major field of study: Finance
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Research interests

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Working papers

- Zexi Wang, 2013, *Financial market, stakeholder relationship, and corporate policies.*
- Zexi Wang, 2013, *Short sellers, institutional investors, and corporate cash holdings.*
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Work experience:

2011 – PRESENT	WRDS Representative at University of Zurich University of Zurich
2010, 2011, and 2012	Teaching Assistant, Advanced Corporate Finance (Master level) University of Zurich

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